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INFLUENCE OF AEROSOLS ON ELECTRICAL PARAMETERS IN THE FREE ATMO--ETC(U)
AUG 78 J M ROSEN, D J HOFMANN DAAG29-77-G-0046

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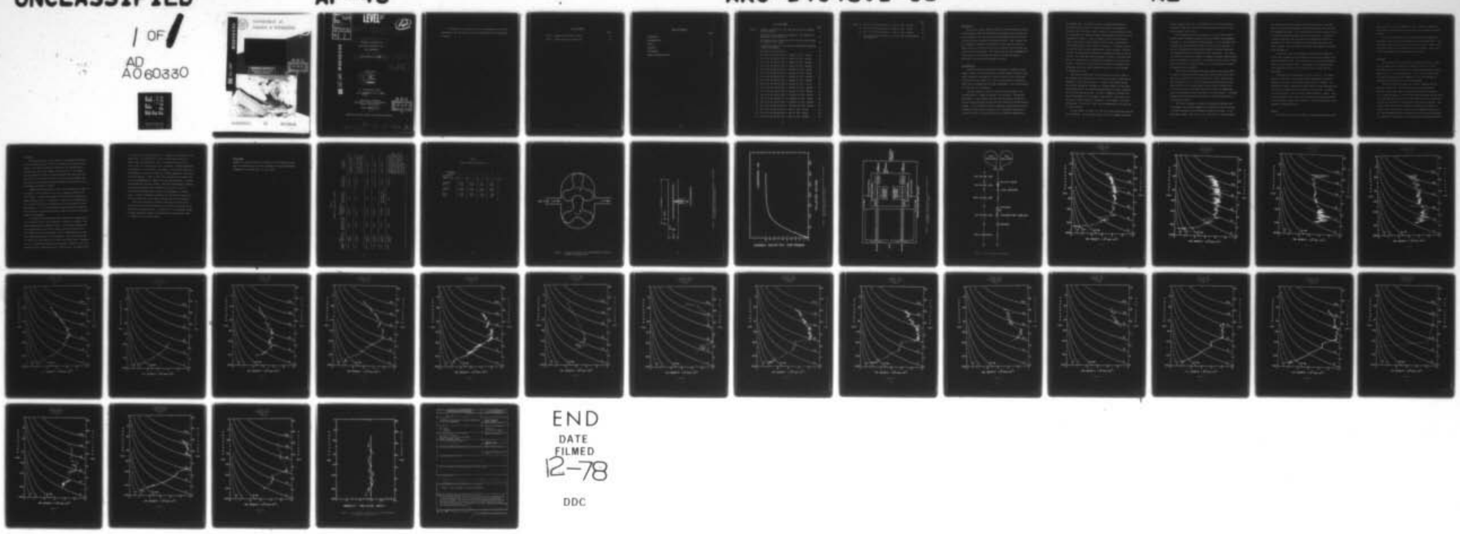

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INFLUENCE OF AEROSOLS ON ELECTRICAL PARAMETERS IN THE FREE ATMOSPHERE

9 INTERIM TECHNICAL REPORT. Aug 77-Aug 78,

12 44p.

Submitted by

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11 Aug[redacted]78

U.S. Army Research Office

Grant Number DAA G 29-77-G-0046 15

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Report Number AP-43 14

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

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Introduction

In an earlier report, Hofmann and Rosen (1975) presented the results of balloon borne small ion concentration measurements using a Gerdien condenser oriented in the vertical direction and employing the natural flow rate derived from ascending and descending balloons. They concluded that the technique as employed did not produce accurate absolute values or produce the correct overall profile and, in addition, did not reflect the true fine scale fluctuations. This report deals with the development and flight testing of an instrument designed to overcome the problems associated with the previously employed technique.

Instrumentation

The basic operating principal of the improved instrument is fairly simple: ambient air is drawn through a Gerdien condenser to which a high enough voltage has been applied to collect essentially all of the small positive ions in the sampled air. The ion concentration is then determined from the sampling flow rate and a measurement of the current between the electrodes of the condenser.

The major change in the newer version of the instrument is the implementation of a steady air supply to the collector. From previous measurements, it was apparent that flow rate fluctuations through the collector caused unwanted and uncorrectable variations in the electrometer current. A fan type pump for the air supply was considered and rejected because this type of device develops a very low pressure head and air currents from the rising payload could cause significant modulation of

the sampling rate. In addition, there is the cumbersome problem of calibrating the flow rate as a function of pressure and temperature. The device that was finally chosen to produce a steady and known air flow was a lobe pump, the schematic diagram and operating principle of which is illustrated in figure 1. Since this pump is made to high tolerances there is very little leakage through the device, and it can develop a very significant head if the intake is closed off. It produces a flow of 2 liters per second, weighs 1 kgm and draws 3 watts of power. The exact flow rate can adequately be determined by measuring the rotation rate of the pump. For flight application the pump is driven by a constant speed motor, the speed of which is measured and telemetered to the receiving station. In addition, the temperature of each pump is measured so that corrections due to the slight warming of the air as it passes through the package can be made.

The design and dimensions of the collector are shown in figure 2. The voltage-current characteristics for flow rates used in flight and for laboratory air are shown in figure 3. On most of the balloon flights the collector voltage was decreased in a stepwise fashion (in two steps) during ascent but was still maintained high enough to collect essentially all of the ions passing through. In order to completely understand and check the operation of the instrument, characteristic curves such as the one shown in figure 3 should be obtained at a large number of altitudes during ascent. The results of this type of measurement will be discussed in a later section.

On some flights (see table 1) a fine wire screen covered the open end of the collector. The screen was made out of .005 cm diameter brass wire

and had a mesh of about 2 mm. Its purpose was to shield the sensitive electrometer input from electrical noise and contain the electric field to the inside of the collector.

For developmental and testing purposes, it was decided to employ a balloon flight instrument package utilizing two complete and independent ion counters. This approach has many advantages. If the instruments and technique are working properly, identical results must be obtained. In this way, fluctuations resulting from unexpected instrumental problems can be separated from real fluctuations in the ion density. Once identical results are achieved the effects of changing instrument characteristics (such as orientation of collector to air stream, fine wire screen covering intake of collector, collector voltage, etc.) can be decisively studied by keeping one unit unchanged.

In the electrical design of the flight package considerable effort was given to keeping the entire conducting outside surface of the instrument at one potential so that there would be no electric field arising from the package itself. This is an important consideration since the actual mobility of ions becomes quite large at high altitude and even a very small electric field would cause ions to move at an appreciable speed and consequently disturb the ambient ion concentrataion. A schematic diagram of the flight package illustrating the shielding precautions is illustrated in figure 4.

The flight instrument is designed to periodically determine the electrometer zero level and respond to a calibration current so that any in-flight variations can be determined and taken into account. It has been found, however, that there is very little drift in the electrometer

zero level and calibration during a typical balloon flight. The pump motors are turned off periodically to provide information for assessing the instrument operation. This would provide an overall system zero level if turbulence did not bring new ions into the collectors. In practice it has been found that the electrometer zero and pump off zero are in agreement for the lower altitudes and in approximate agreement at the higher altitude. The exact reason for the small discrepancy is presently being investigated.

In the early stages of development it was found that commercial coaxial cable deformed and flexed slightly during pressure changes associated with balloon ascent. This flexure gave rise to noticeable fluctuations in the electrometer output. The problem was corrected by using solid non-flexible coaxial cables connecting the collector with the electrometer.

The flight train configuration is shown in figure 5. Two rubber balloons rather than a single larger plastic balloon were used which afforded a slow descent in the event only one burst at altitude. The equipment was usually launched well before sunrise so that the package was not in direct sunlight until the balloon was near ceiling. The double balloon system gave a slow rise rate of about 200 meters a minute. Fast ascent and descent rates seemed to be associated with large fluctuations in the electrometer output and, therefore, a slowly moving balloon is now thought to be highly desirable.

Results

The results of the first 6 flights, including descents where avail-

able, are shown in figures 6 through 26. Table 1 presents a summary of these flights along with notes describing the relevant changes in configurations.

In the ion density profiles an attempt was made to represent the fluctuations as observed on the original chart record during flight. This was done by taking a data point every four seconds which is three or four times shorter than the time constant of the electrometers. Thus, essentially no smoothing of the original data has been made.

Discussion

The influence of the collector tube orientation in the air stream can be estimated from a comparison of flights 171 and 175. In the horizontal position, the collectors are diametrically opposed as shown in figure 4 with a .5 cm gap between them. In the vertical position they are both facing upward into the oncoming air. In these examples the orientation does not seem to be of great importance.

The effect of the wire screen can be seen by comparing the two profiles of flight 175: the unit with the wire screen apparently measures a significantly lower ion concentration than the unscreened unit. During the pump off zero both electimeters displayed the same value indicating that the fringe electric field associated with the unscreened unit was not responsible for drawing extra ions into the collector. This suggests that there may be an important diffusional loss around the intake of the collector tubes and that further experiments dealing with this loss phenomenon should be undertaken, since such losses would reduce the apparent ion concentration in the stratosphere as measured with this

instrument.

An identification of the true nature of the apparent fluctuations in the ion density profile is one of the important first steps in this research. The profiles themselves suggest that the fluctuations are less with low ascent rates (compare flight 155 with 175 for example). A close examination of the two profiles obtained from flight 155 shows that there is no correlation in the fine structure which suggests that the fine scale fluctuations encountered during this flight are not real and probably instrumental artifacts.

Although the descent profiles of the ion concentration are shown in the figures, certain caution must be used in comparing them with the ascent values. As previously suggested, the high speed of descent may produce erroneous values. In addition, in some cases the orientation of the collector tubes for descent operation are exactly opposite to what they should be. It will be noted that on some occasions the ascent and descent profiles agree fairly well and in other cases there is noticeable amounts of disagreement,

In flight W-178 an attempt was made to measure the voltage-current (V-1) characteristics of the collector as a function of altitude. The actual voltages used are shown in table 2. It was later concluded that the system exhibits a zero off-set voltage error such that with zero volts applied to the collector there is still a measurable and in some cases significant current to the electrometer. The nature of this off-set needs to be investigated to a greater extent before the V-1 characteristics as a function of altitude can be presented. However, it is still possible to derive some useful results from this data. The slope of the

V-1 curves in the low voltage region is a constant and proportional to the conductivity. The conductivity in turn is proportional to the ion mobility and ion concentration. Thus, dividing the slope of the V-1 curves in the low voltage region by the ion density, a number proportional to the mobility can be obtained. This number is then usually multiplied by the ambient air density to remove the altitude dependence. The results of such an analysis is shown in figure 27 using the data of flight W-178. To a first approximation, it appears that the reduced mobility is constant with altitude over the range studied. With more careful analysis absolute values could be obtained, but the emphasis at this time is on the variations with altitude rather than precise measurements of absolute values. In future soundings the problems that developed in flight W-178 will be corrected and a more complete analysis will then be presented.

Plans are now being made to obtain simultaneous aerosol and ion density profiles so that the influence of particulates on the ion concentration can be studied directly. In addition, it is also planned to make in-flight comparisons between this instrument and similar devices used by a number of other research groups.

Bibliography

Hofmann, D.J. and J.M. Rosen, The influence of CN and aerosols on the small ion concentration in the free atmosphere, University of Wyoming Atmospheric Physics Report GM - 31, June, 1975.

TABLE I

SUMMARY OF ION DENSITY FLIGHTS

Flight Number	Date and Local Launch Time	Associated Ion Chamber Flight	Average Rise/ Descent Rate (m/min)	Wire Screen On Collector	Orientation Of Collectors	Collector Voltages
W-155	8/19/77 09:02	None	230/1046	Yes	horizontal	153 volts on collector throughout flight.
W-162	10/12/77 04:31	W-163	194/377	Yes	horizontal	153 volts from ground to 10 km - 50 volts from 10 km to 18 km - 20 volts above 18 km
W-164	10/20/77 04:29	W-165	197/1025	Yes	horizontal	Same as W-162
W-170	2/24/78 05:18	W-171	198/440	No	horizontal	Same as W-162
W-175	5/10/78 02:48	W-176	168/1090	one with (I) one without (II)	vertical	Same as W-162
W-178	5/23/78 04:03	None	195/1110	No	vertical	Voltage levels on one collector switched at 1 minute intervals according to table 2. Other collector voltage 207 from ground level to 10 km, 71 volts from 10 km to 18 km and 24 volts above 18 km.

TABLE 2

VOLTAGE STEPS FOR FLIGHT W-178

Altitude Range \ Voltage Range	1	2	3	4
ground to 10 km	32.5 volts	16.25 volts	8.13 volts	4.06 volts
10 km to 18 km	10.4 volts	5.20 volts	2.60 volts	1.30 volts
Above 18 km	2.60 volts	1.30 volts	.650 volts	.325 volts

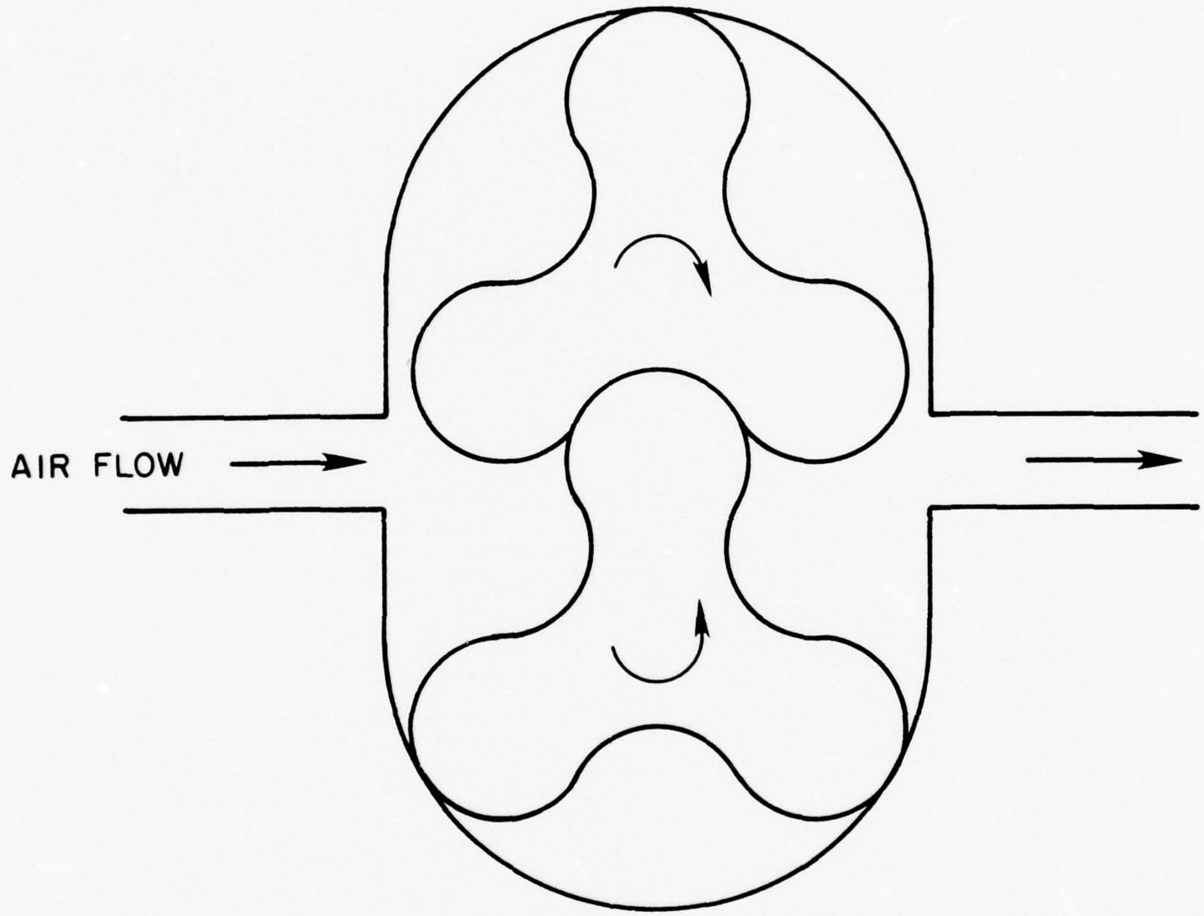

Figure 1. Schematic diagram of the lobe pump used to draw air through the ion collector.

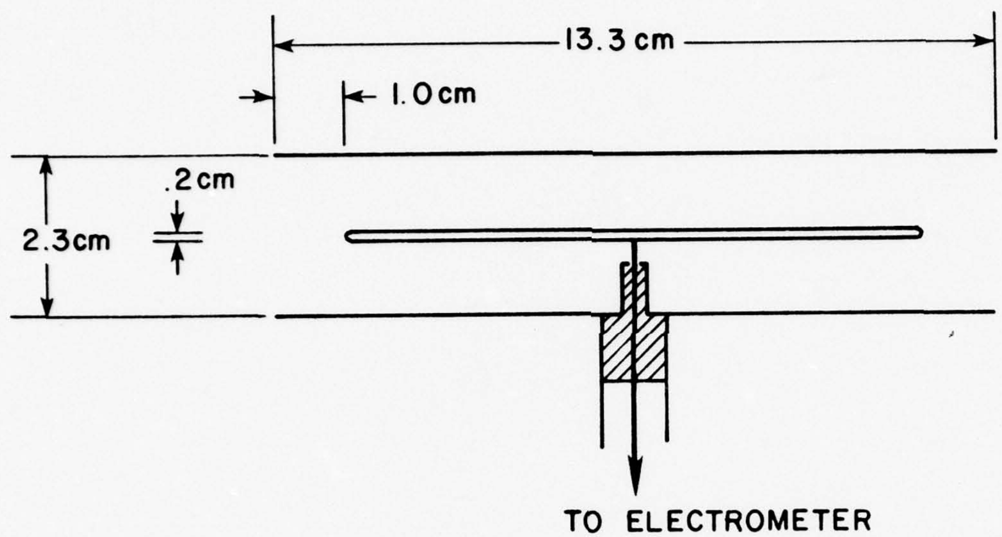

Figure 2. The collector tube showing the dimensions. The shaded area represents teflon insulation.

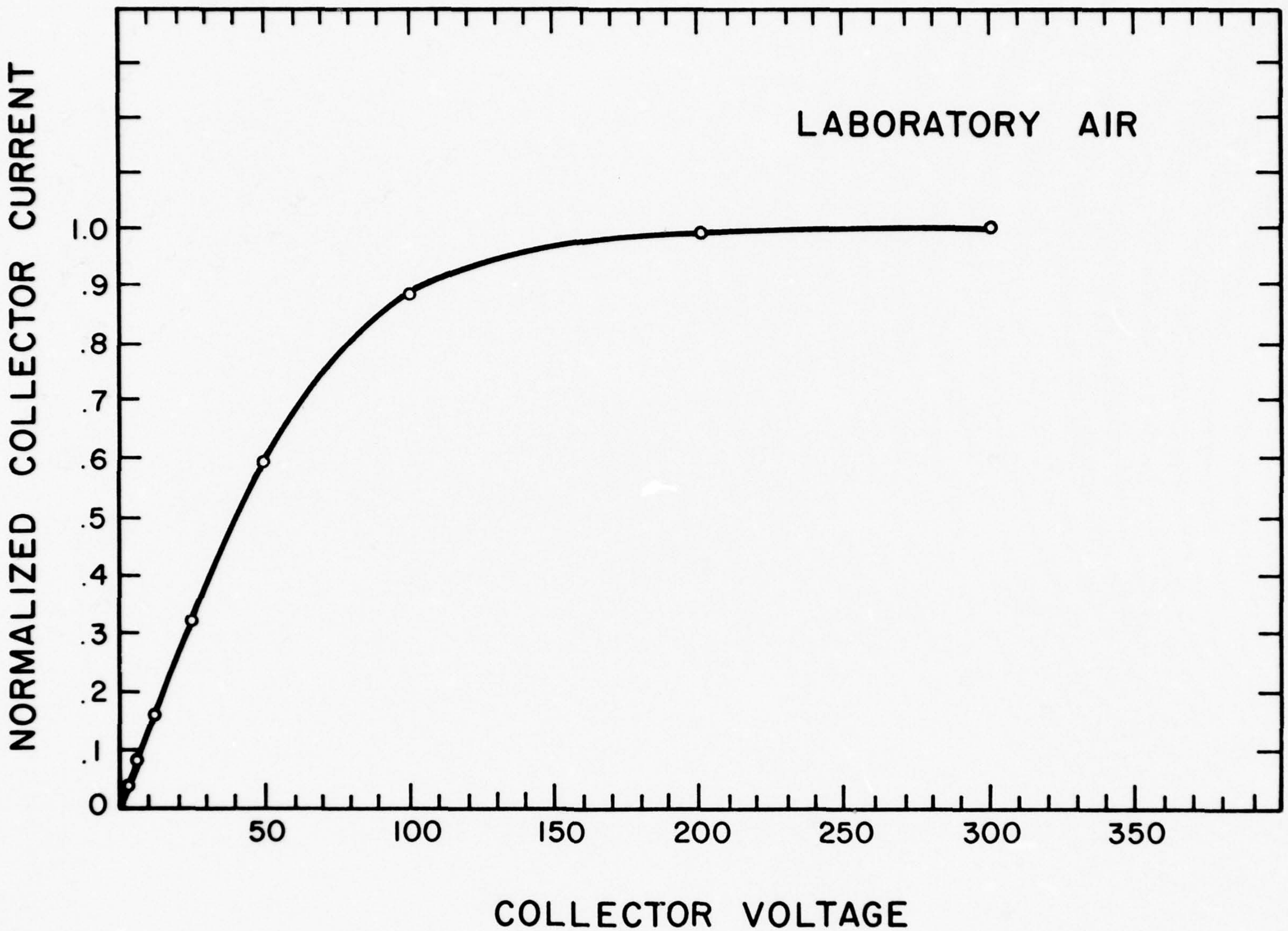

Figure 3. The voltage-current characteristics of the ion collector tube at a flow rate of 2 l/min.

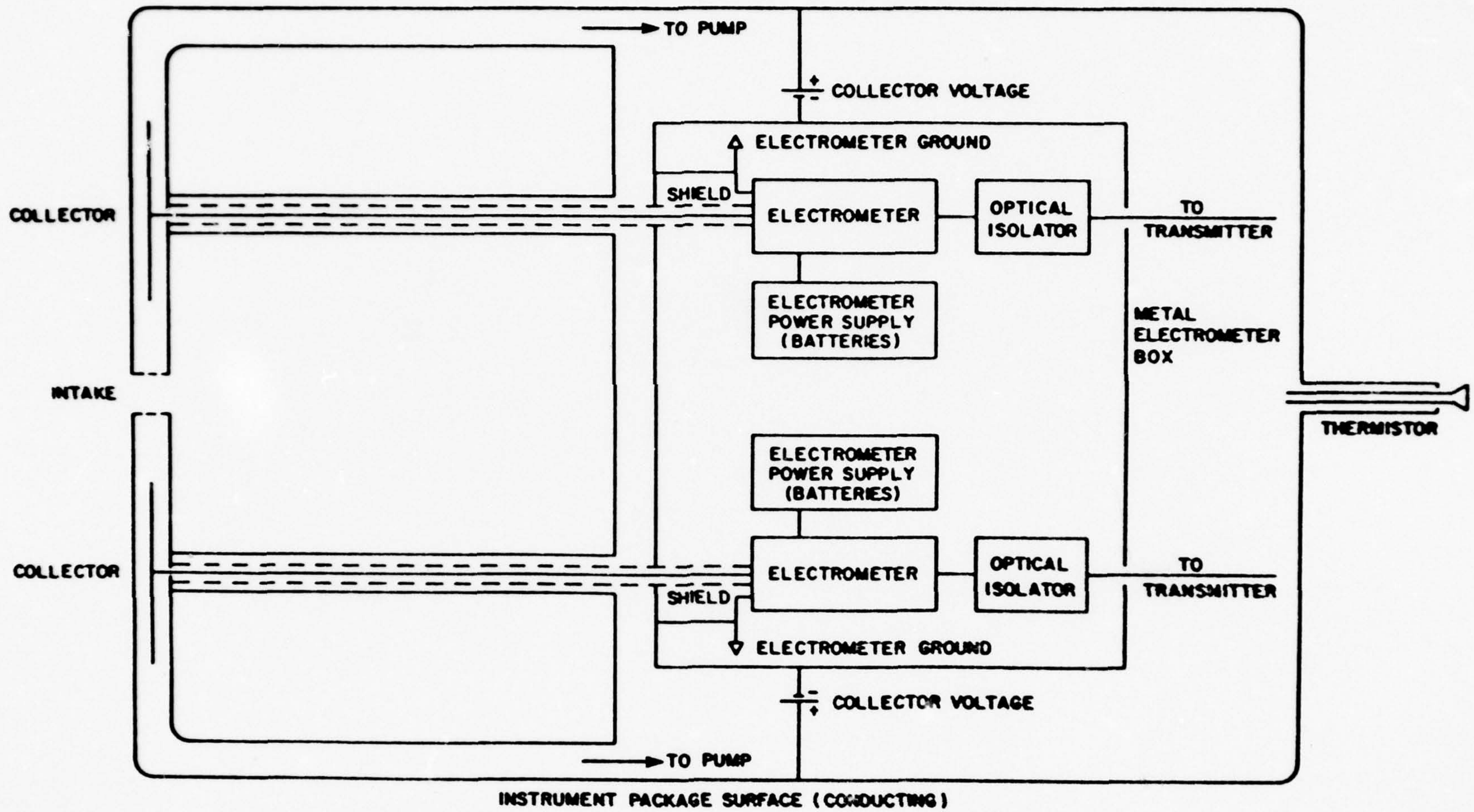

Figure 4. A schematic diagram of the electronic configuration shielding in the flight package.

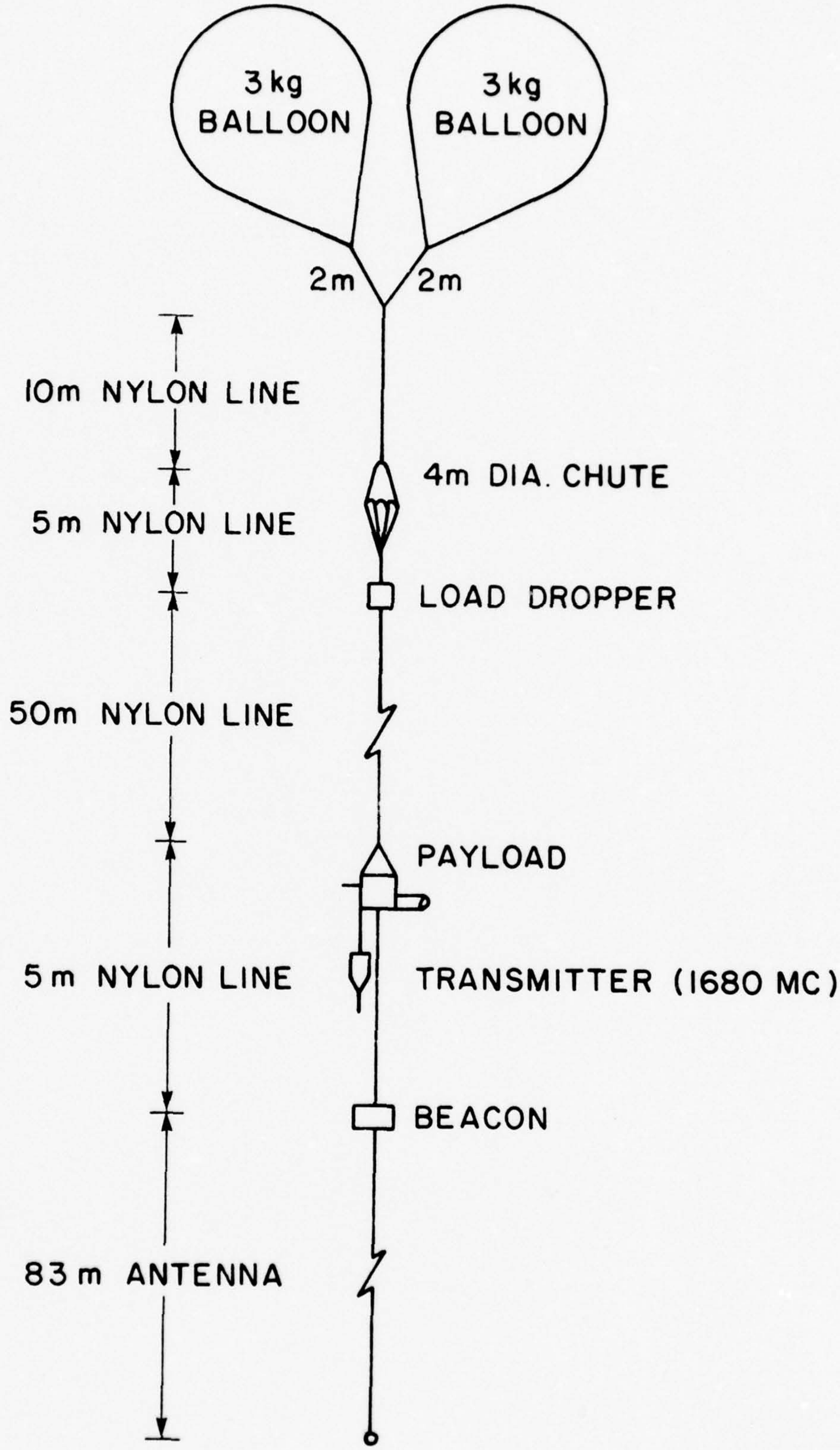

Figure 5. The load train configuration.

FLT. W - 155
ION DENSITY UNIT I
AUG 19, 1977
ASCENT

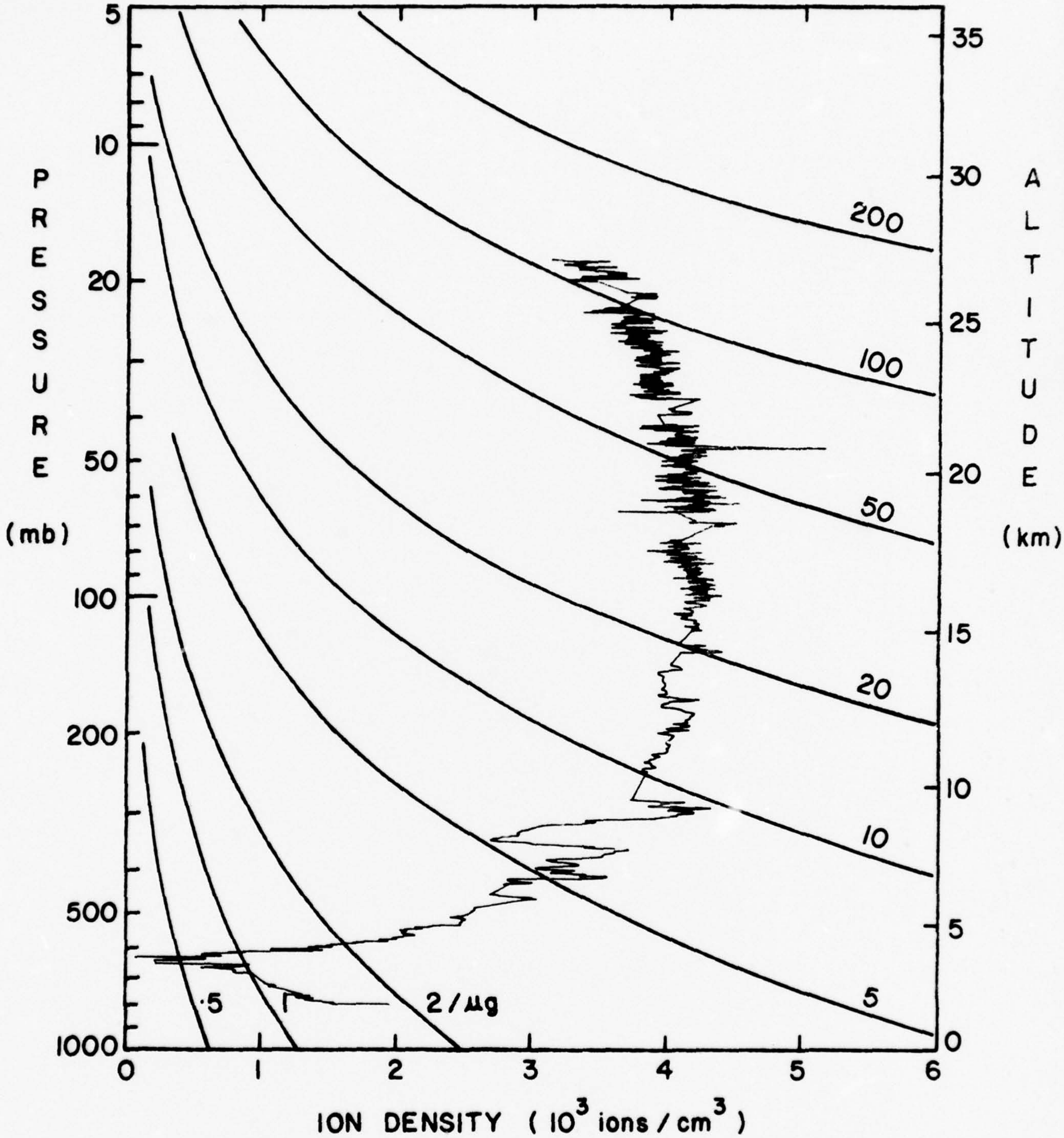

Figure 6.

FLT. W - 155
ION DENSITY UNIT II
AUG 19, 1977
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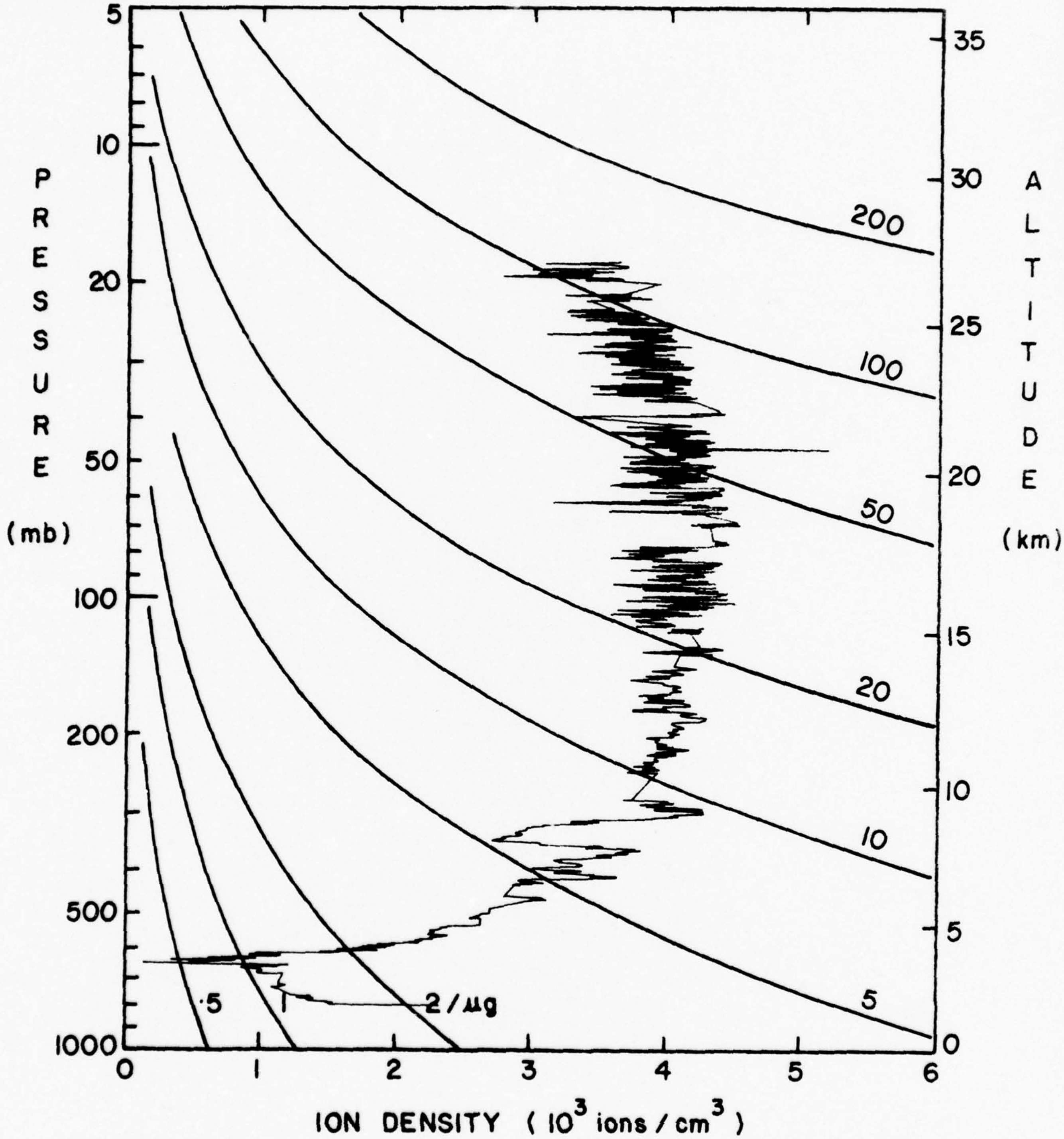

Figure 7.

FLT. W - 155
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AUG 19, 1977
DESCENT

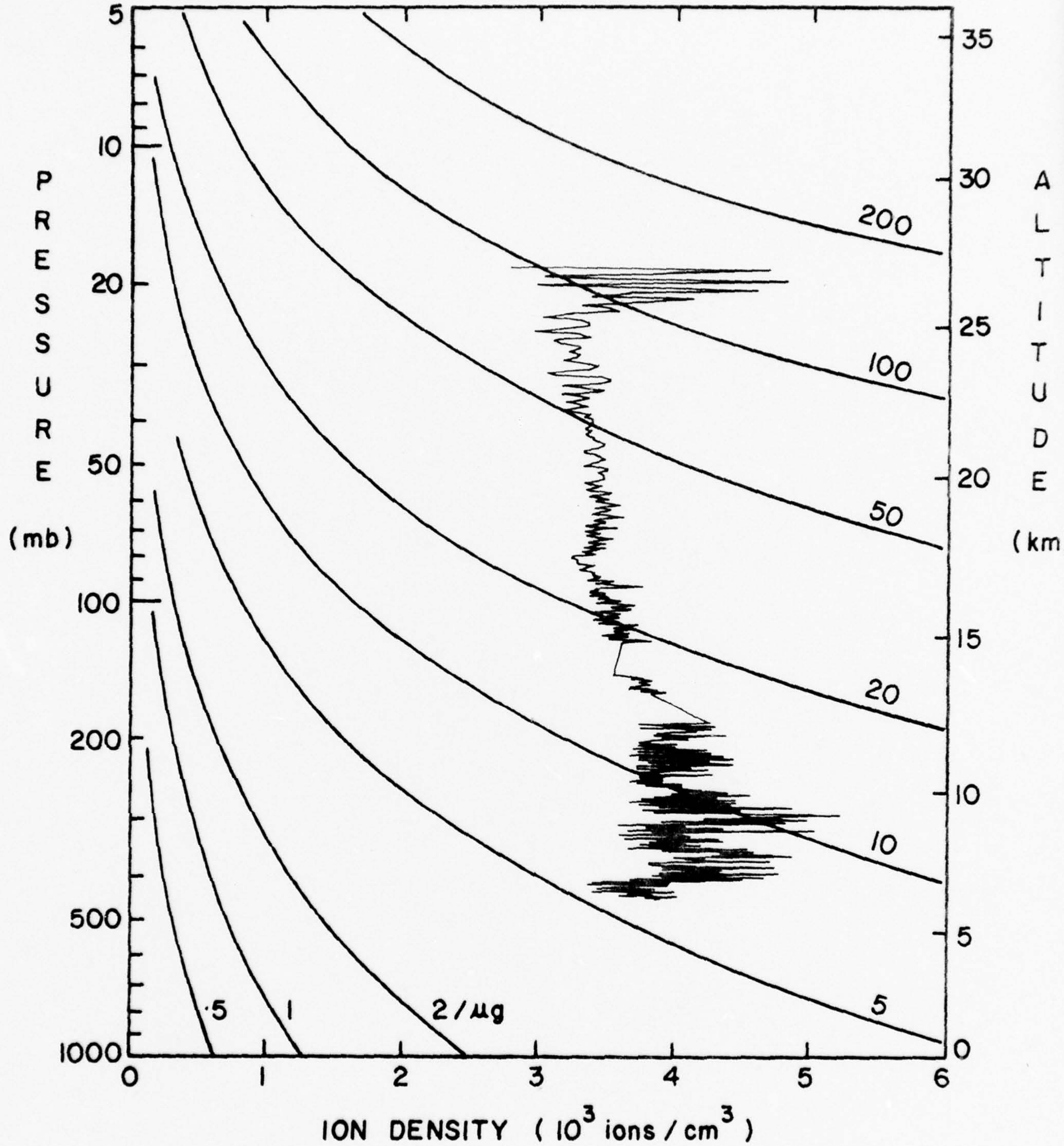

Figure 8.

FLT. W - 155
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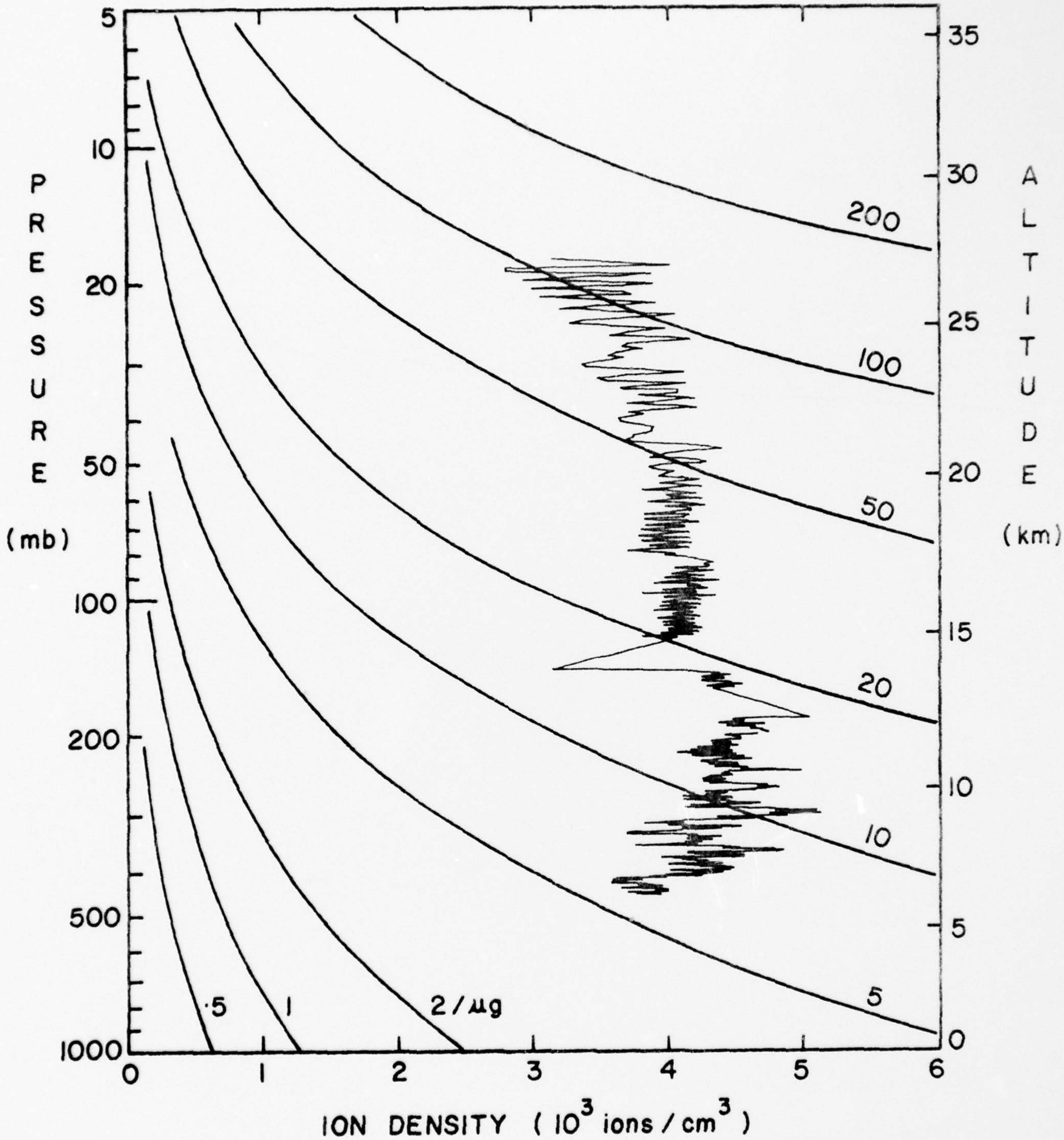

Figure 9.

FLT. W - 162
ION DENSITY UNIT I
OCT 12, 1977
ASCENT

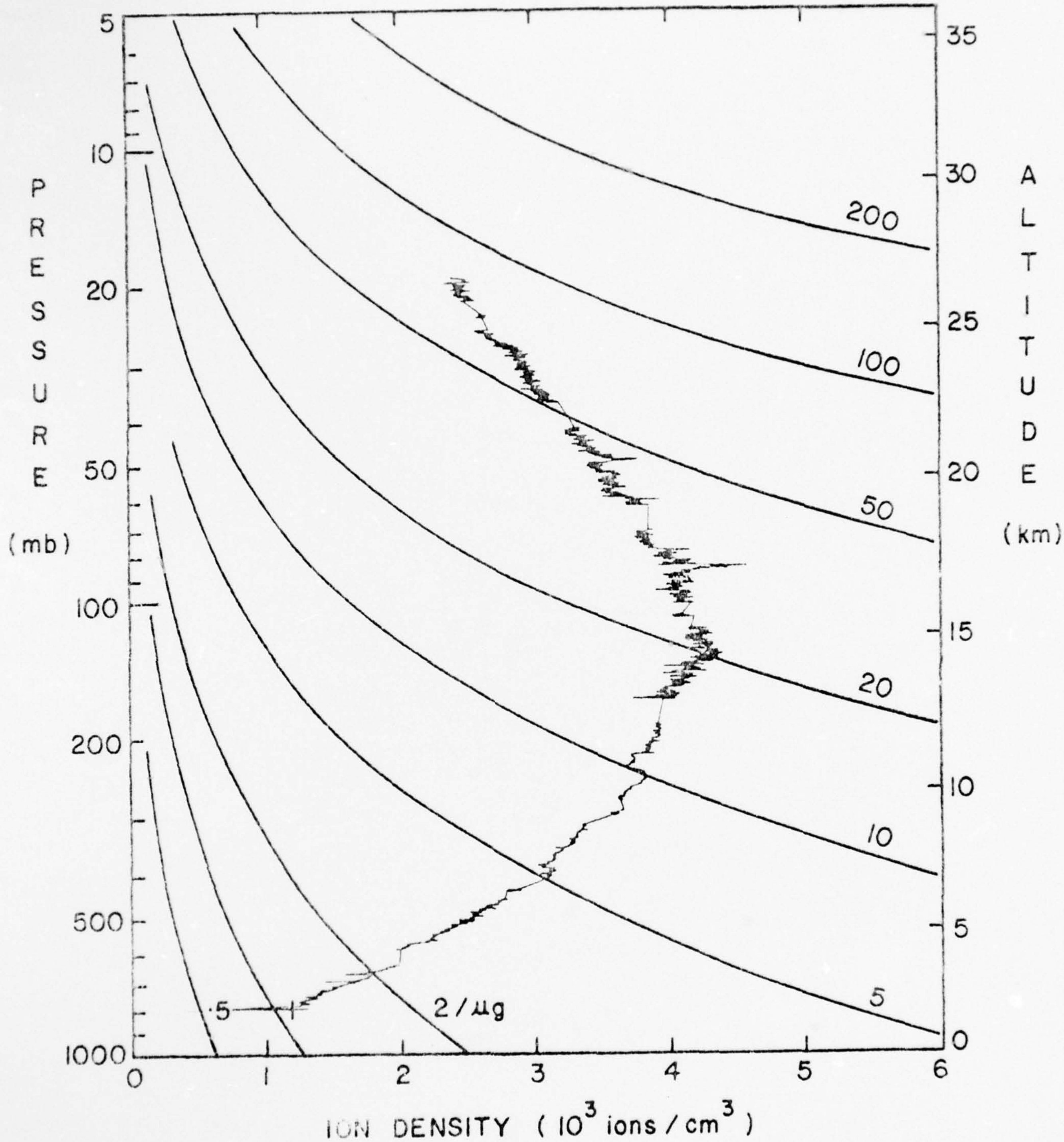

Figure 10.

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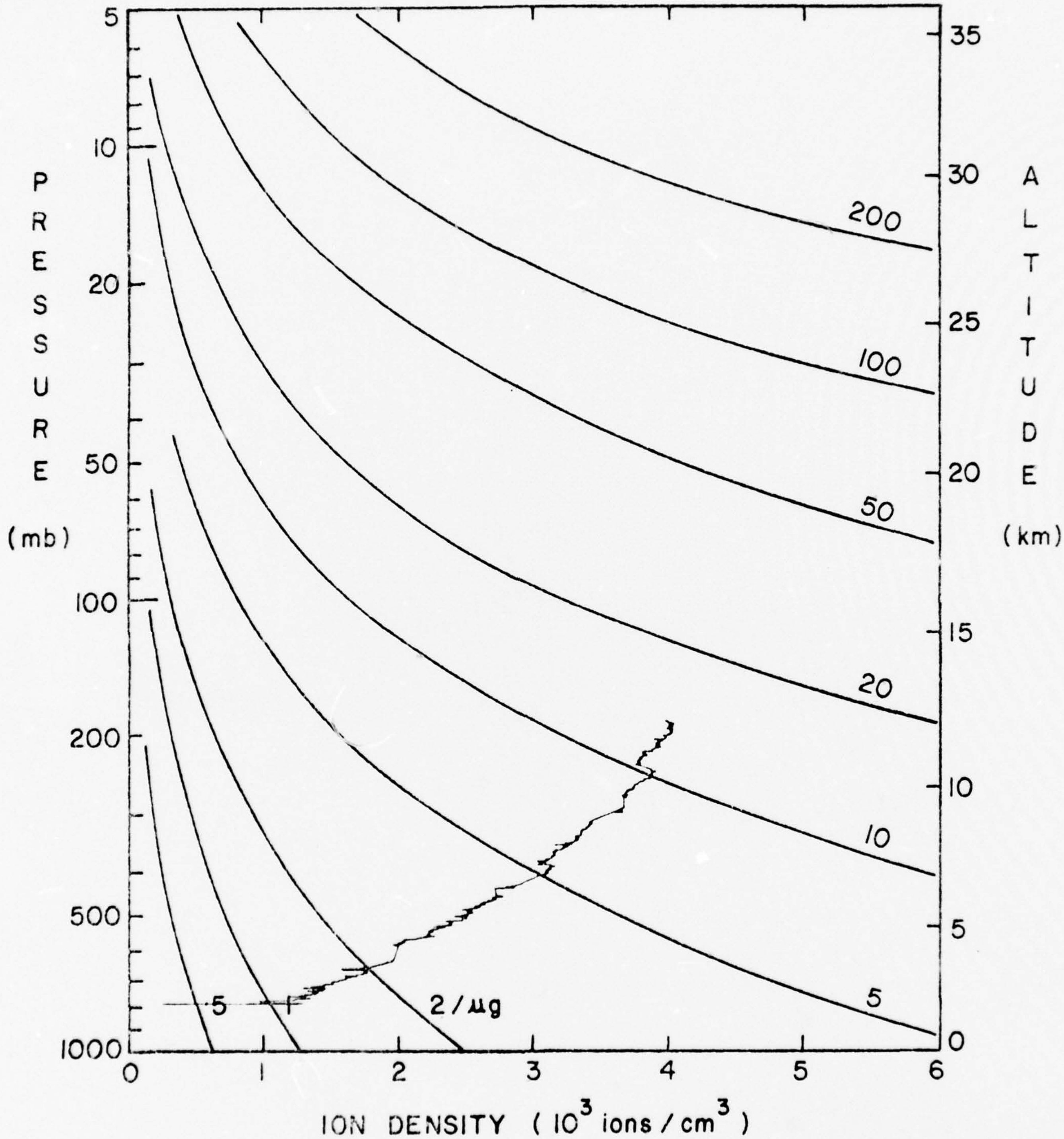

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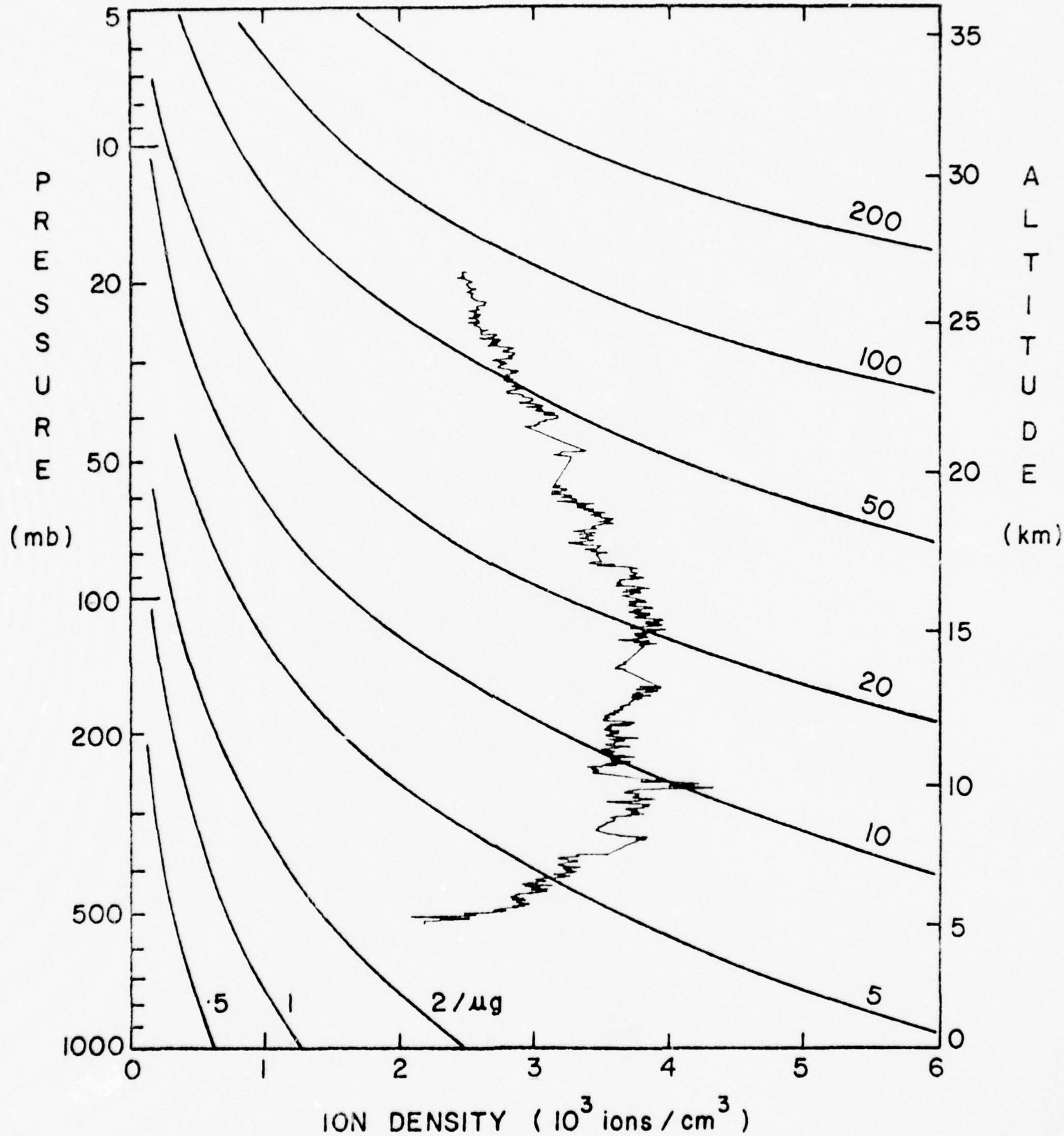

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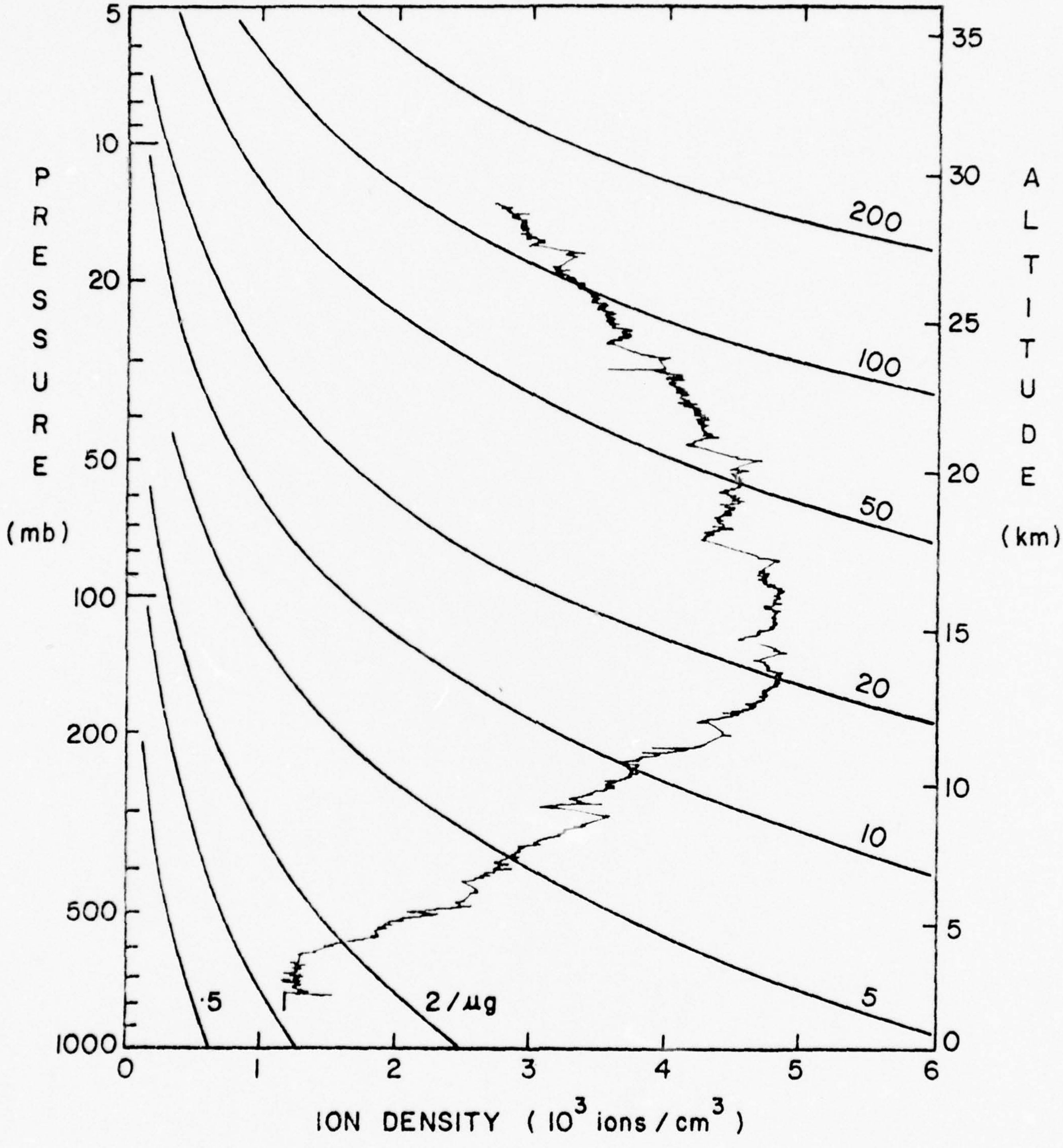

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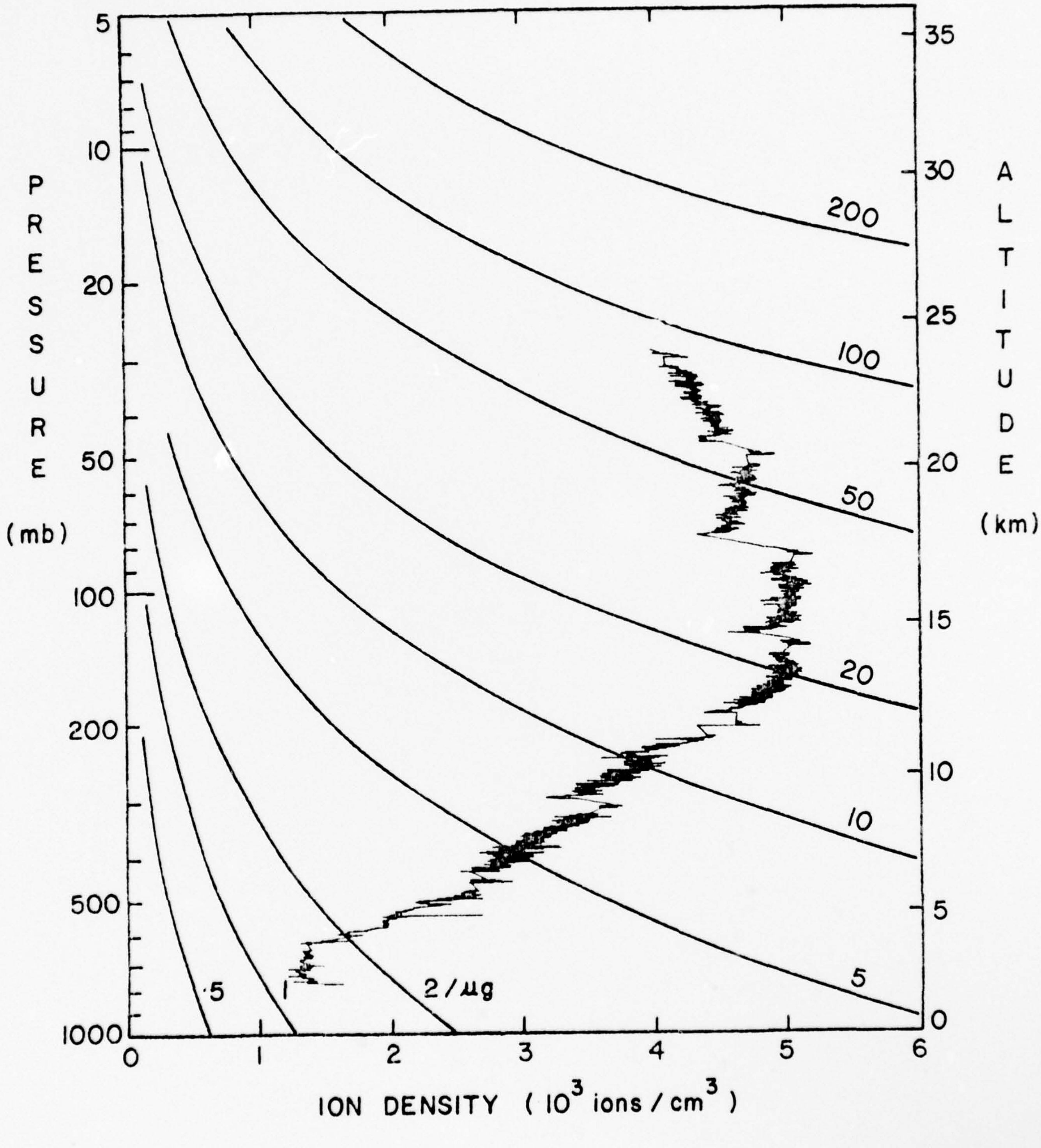

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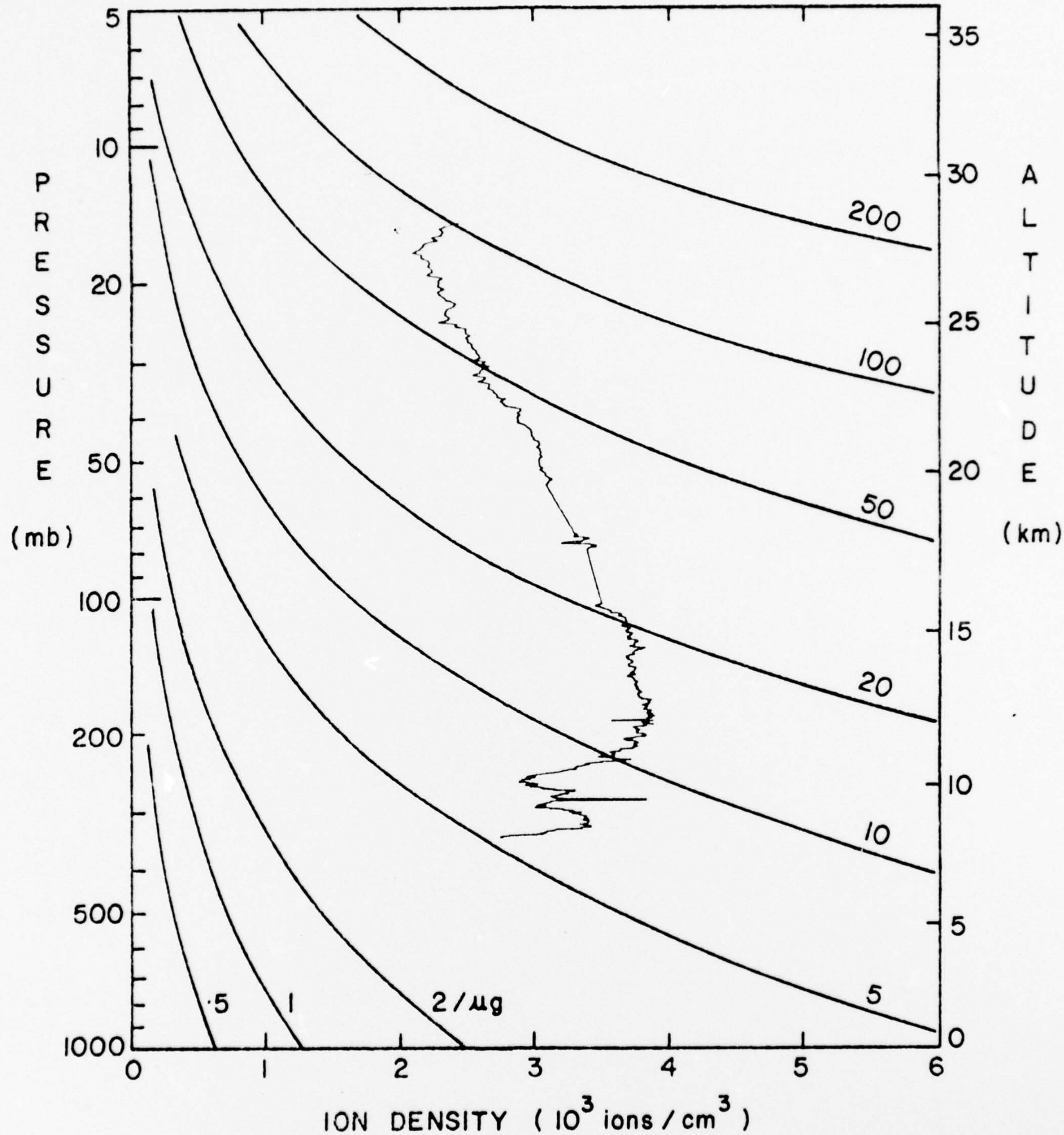

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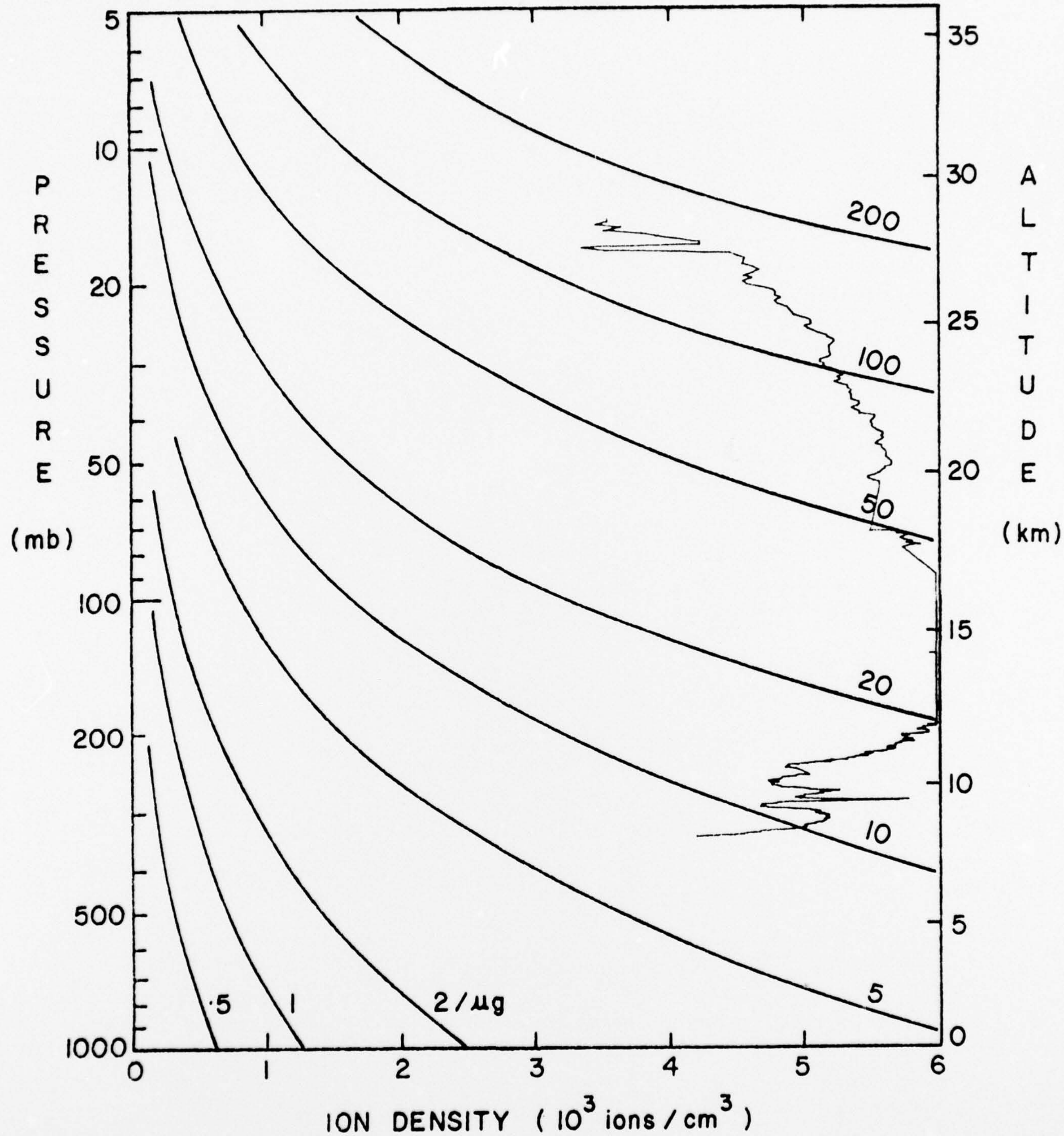

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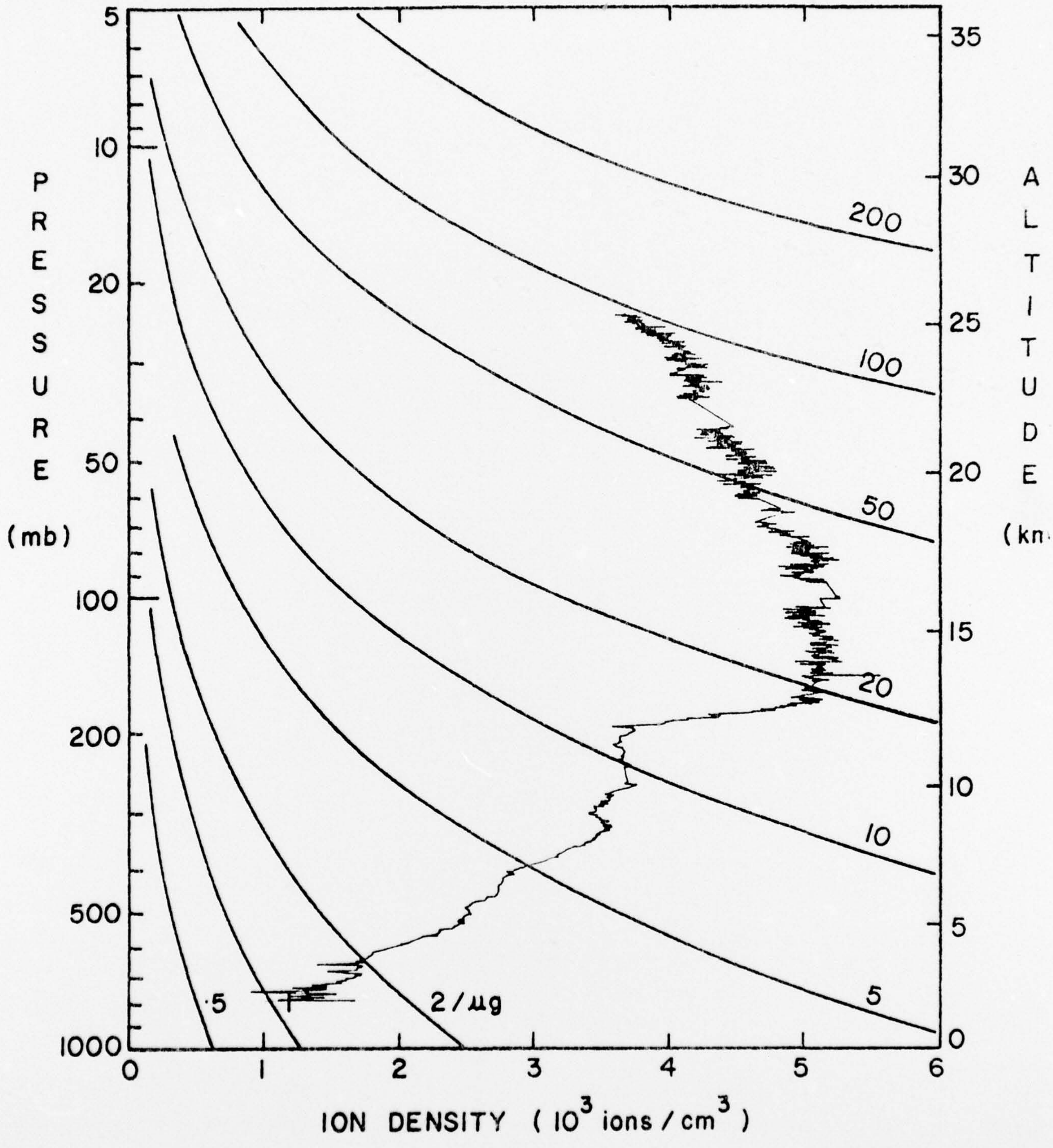

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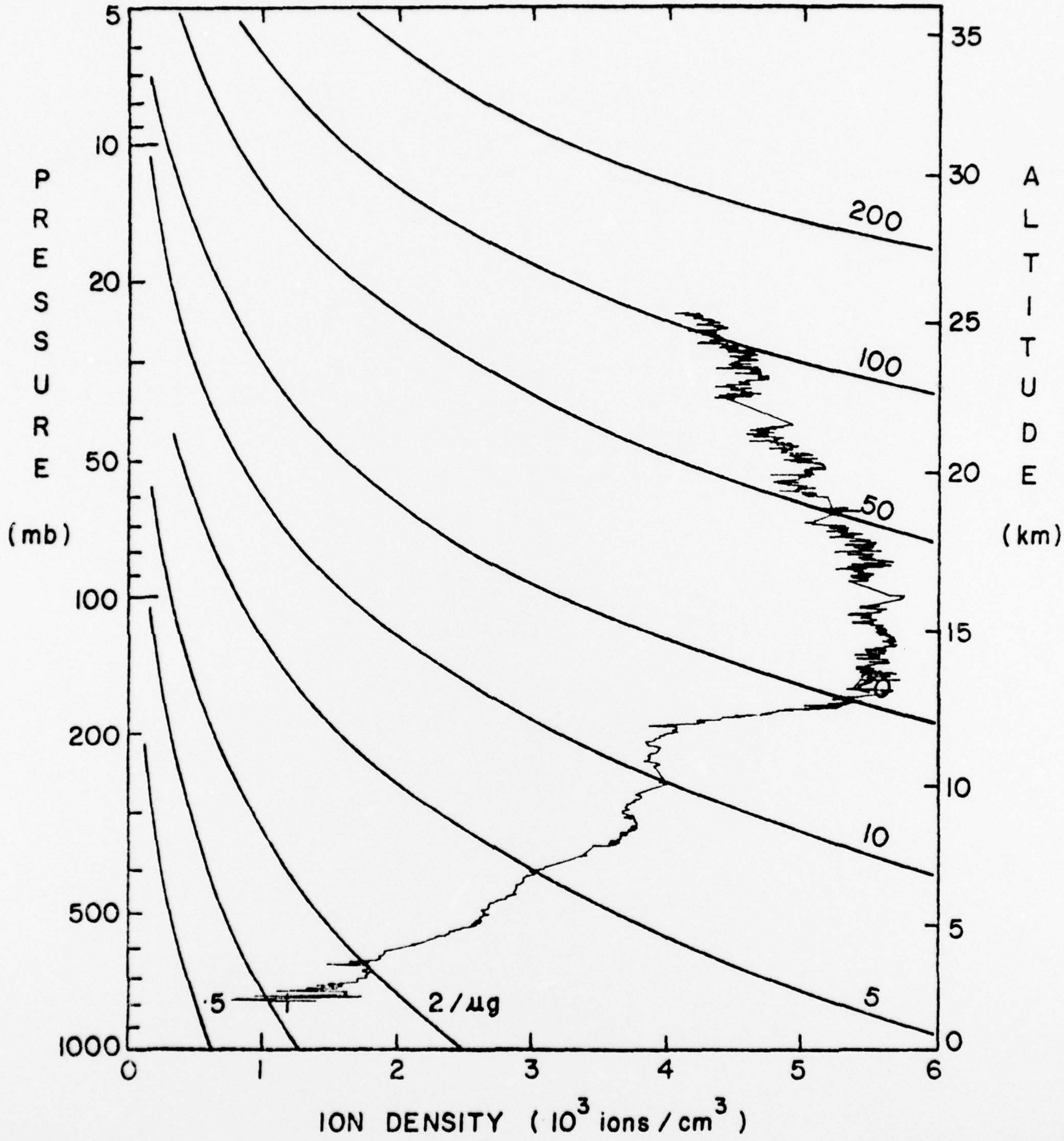

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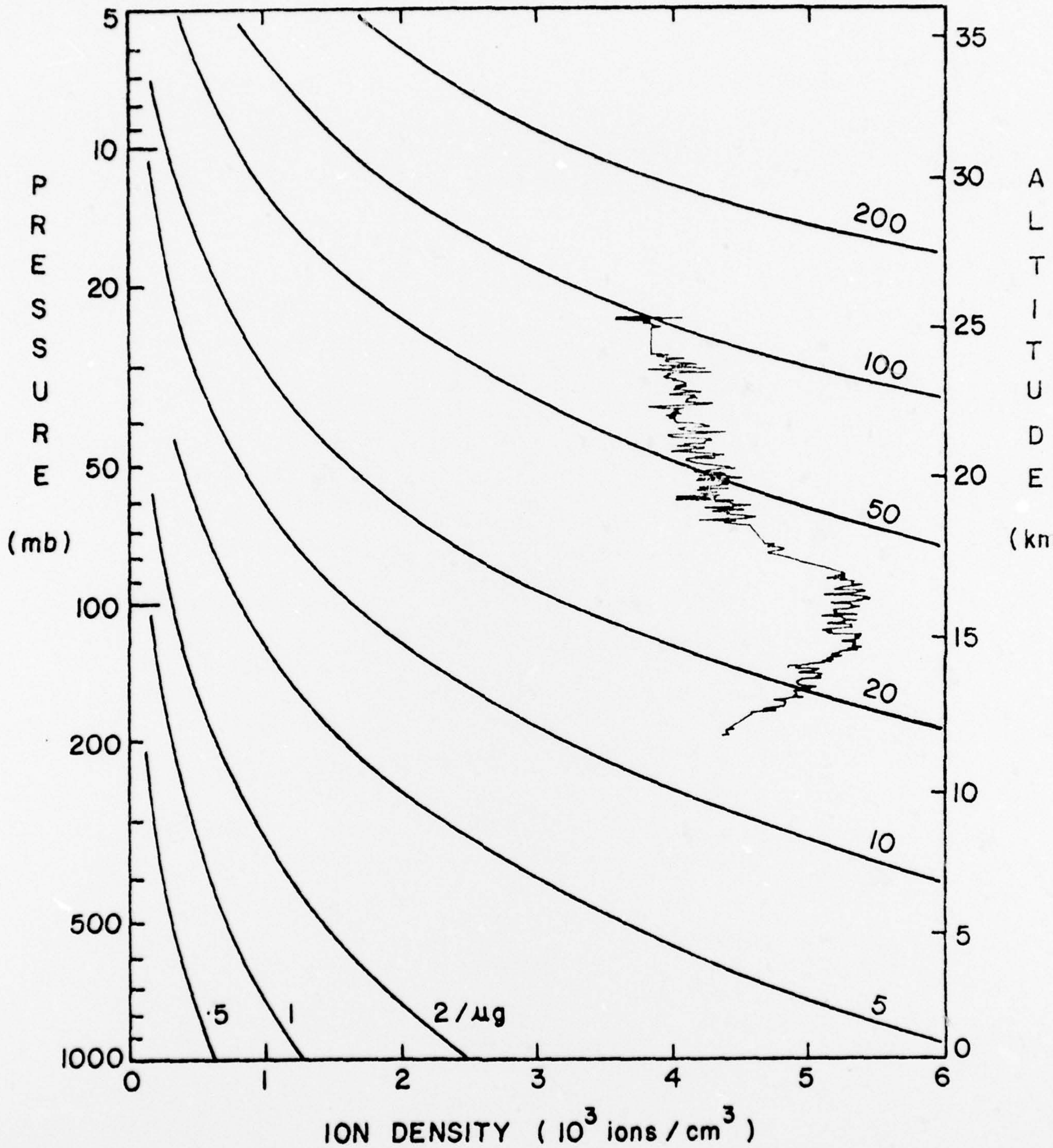

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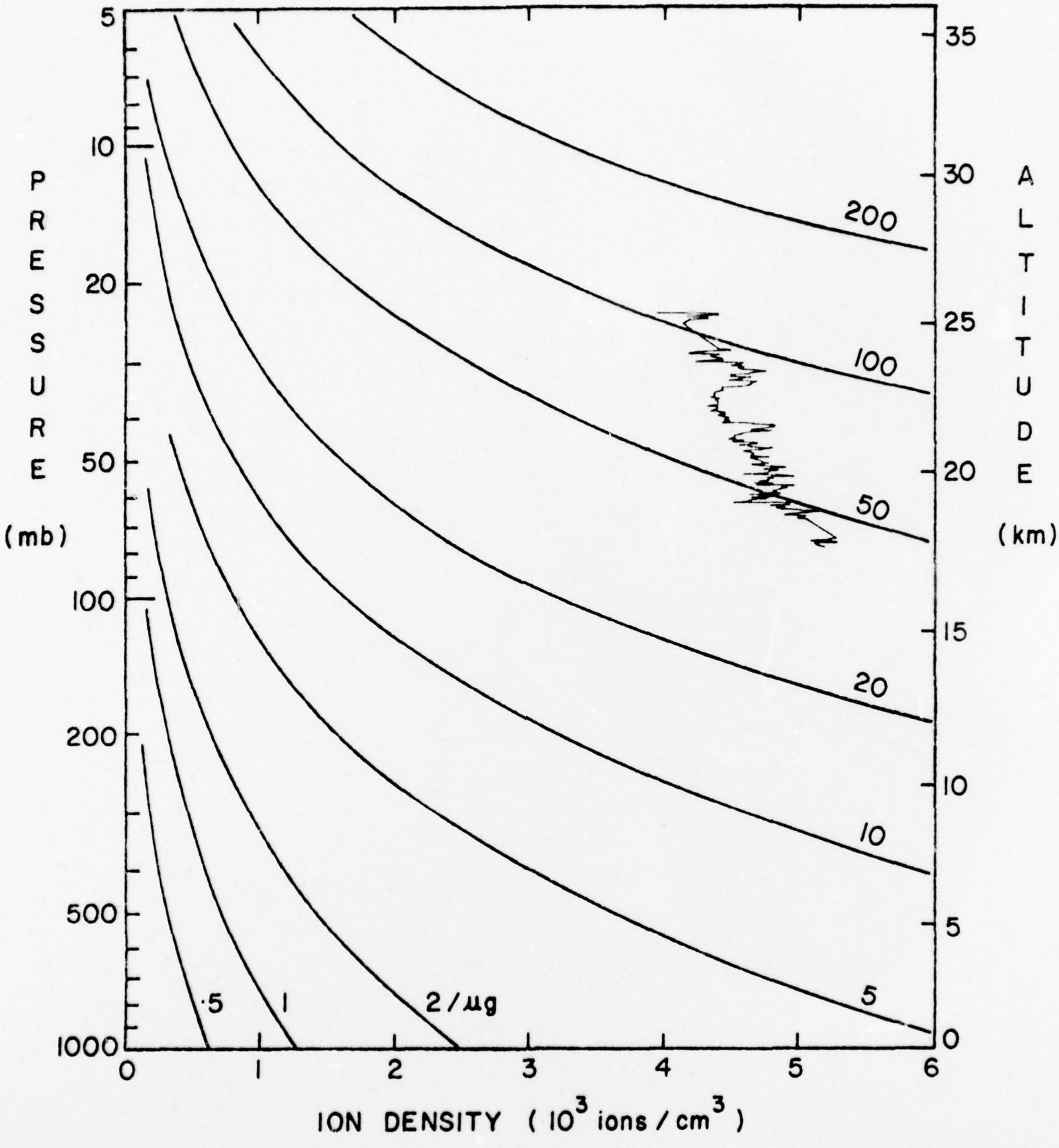

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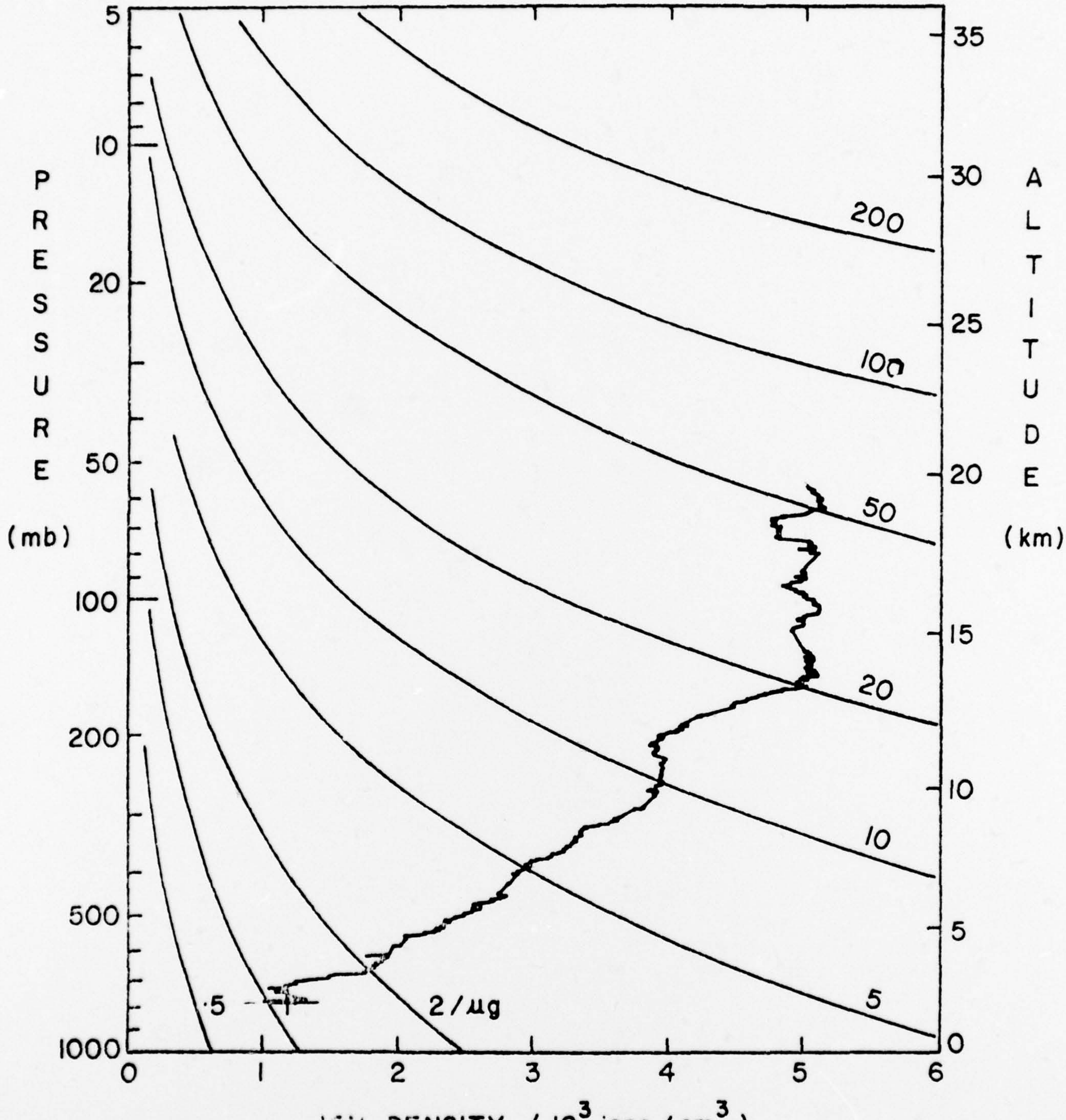

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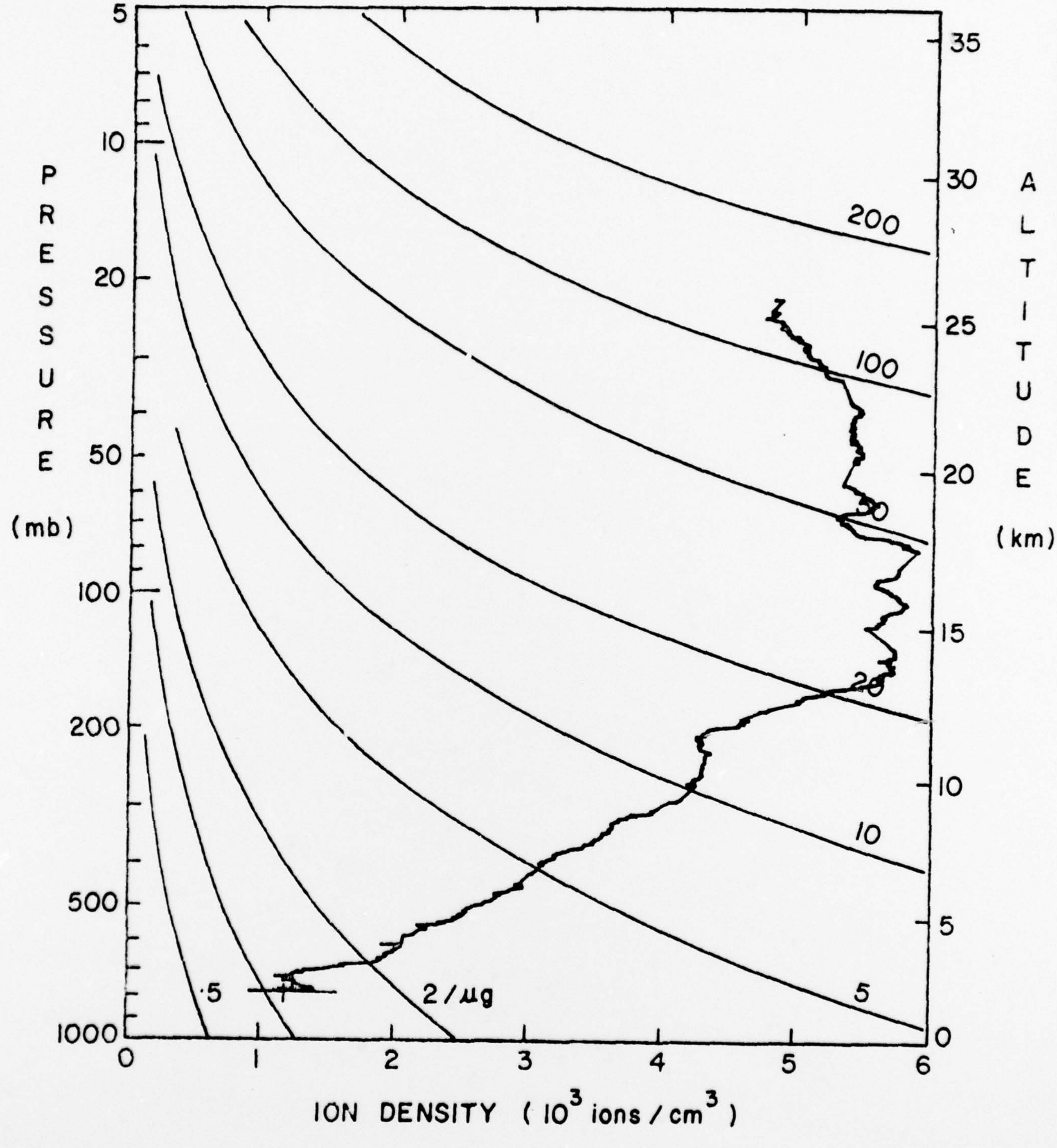

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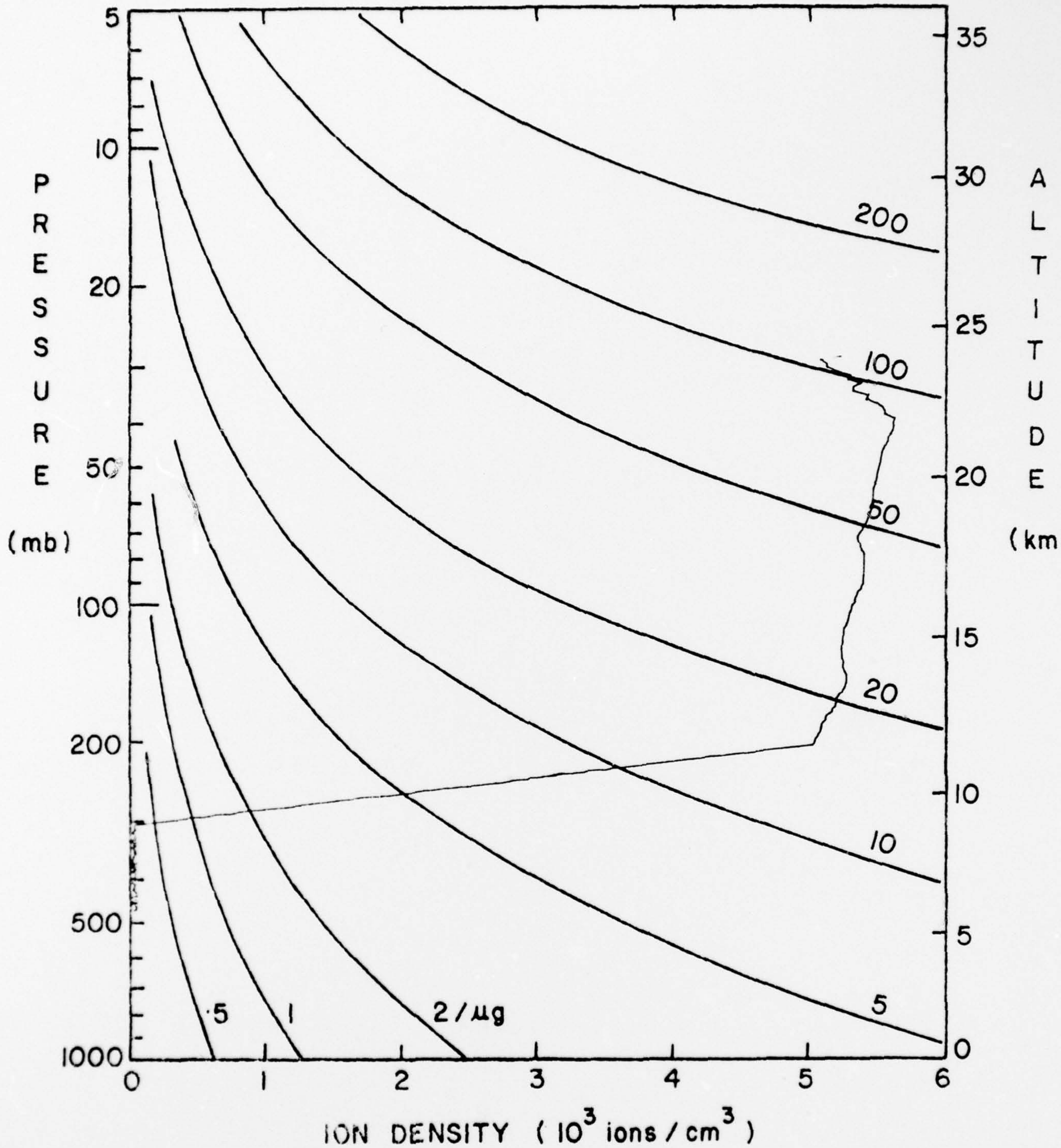

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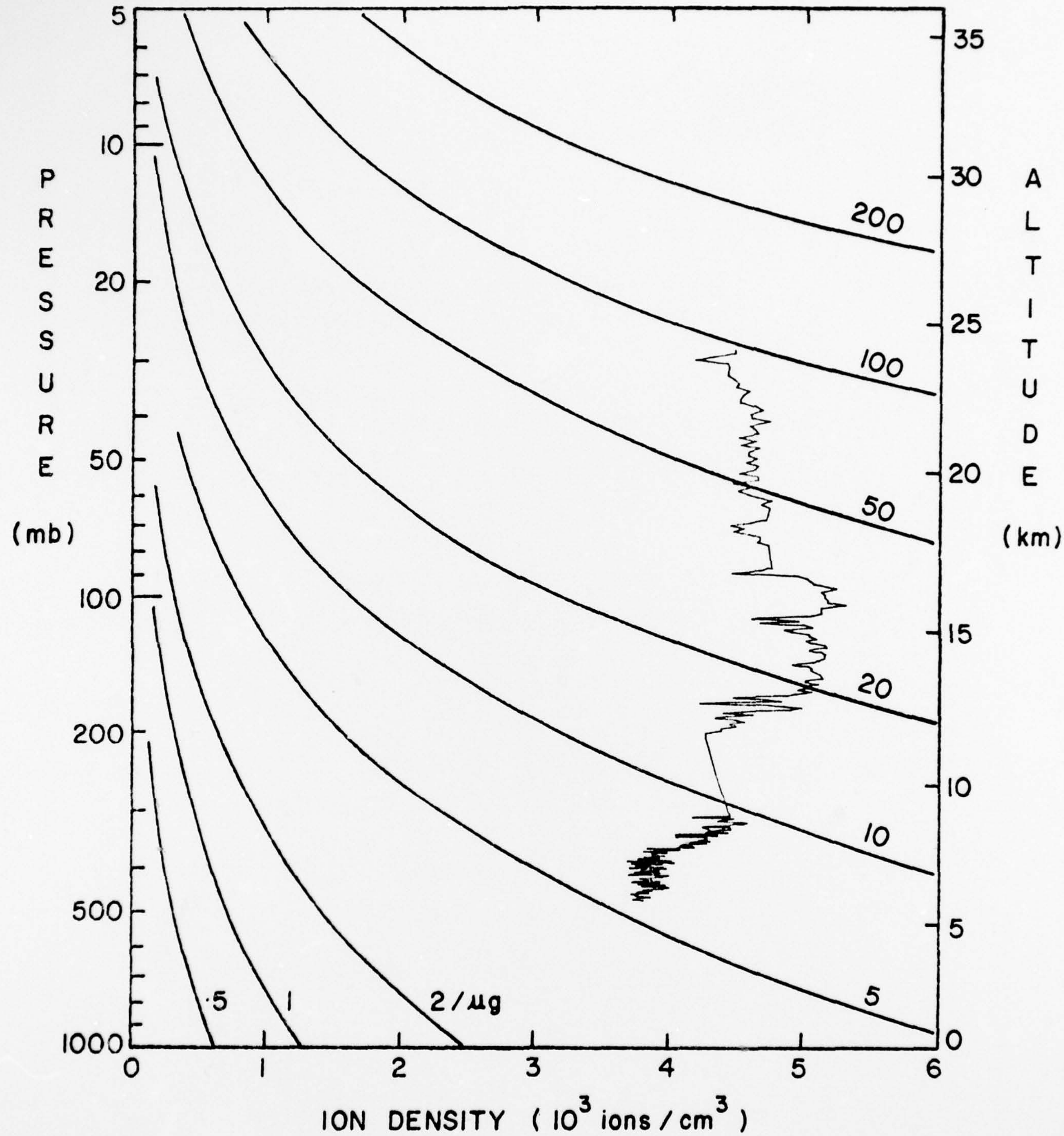

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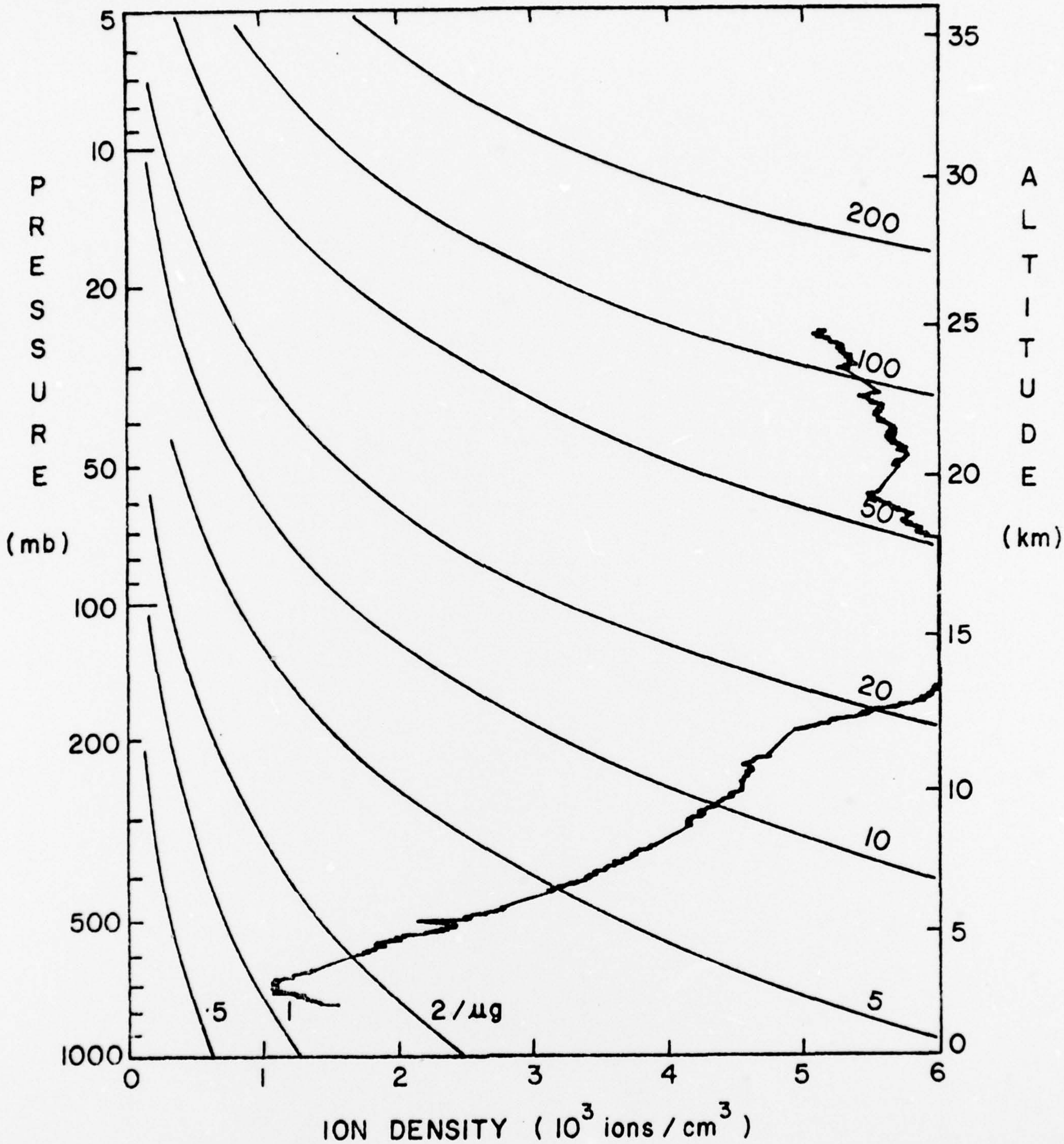

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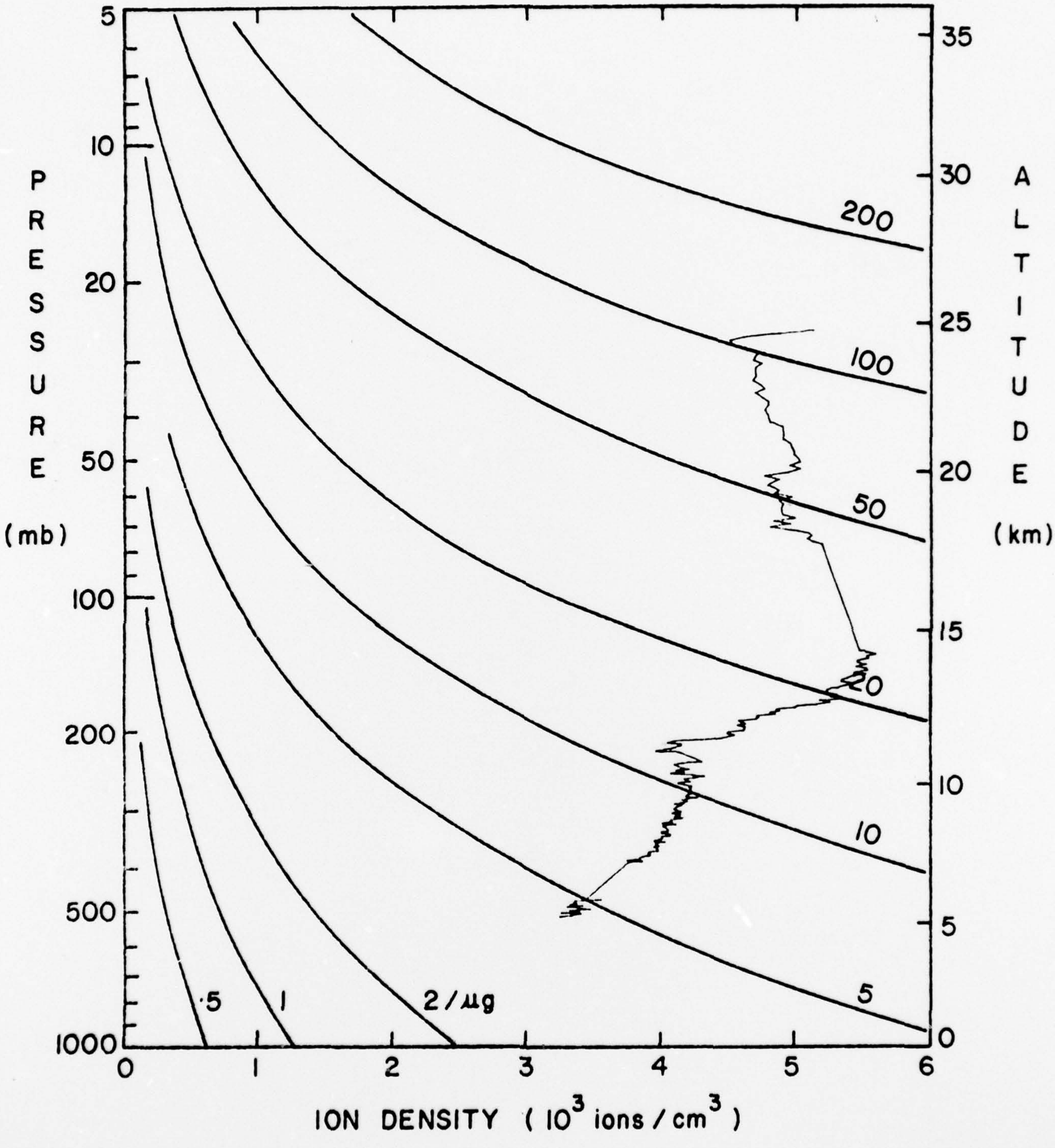

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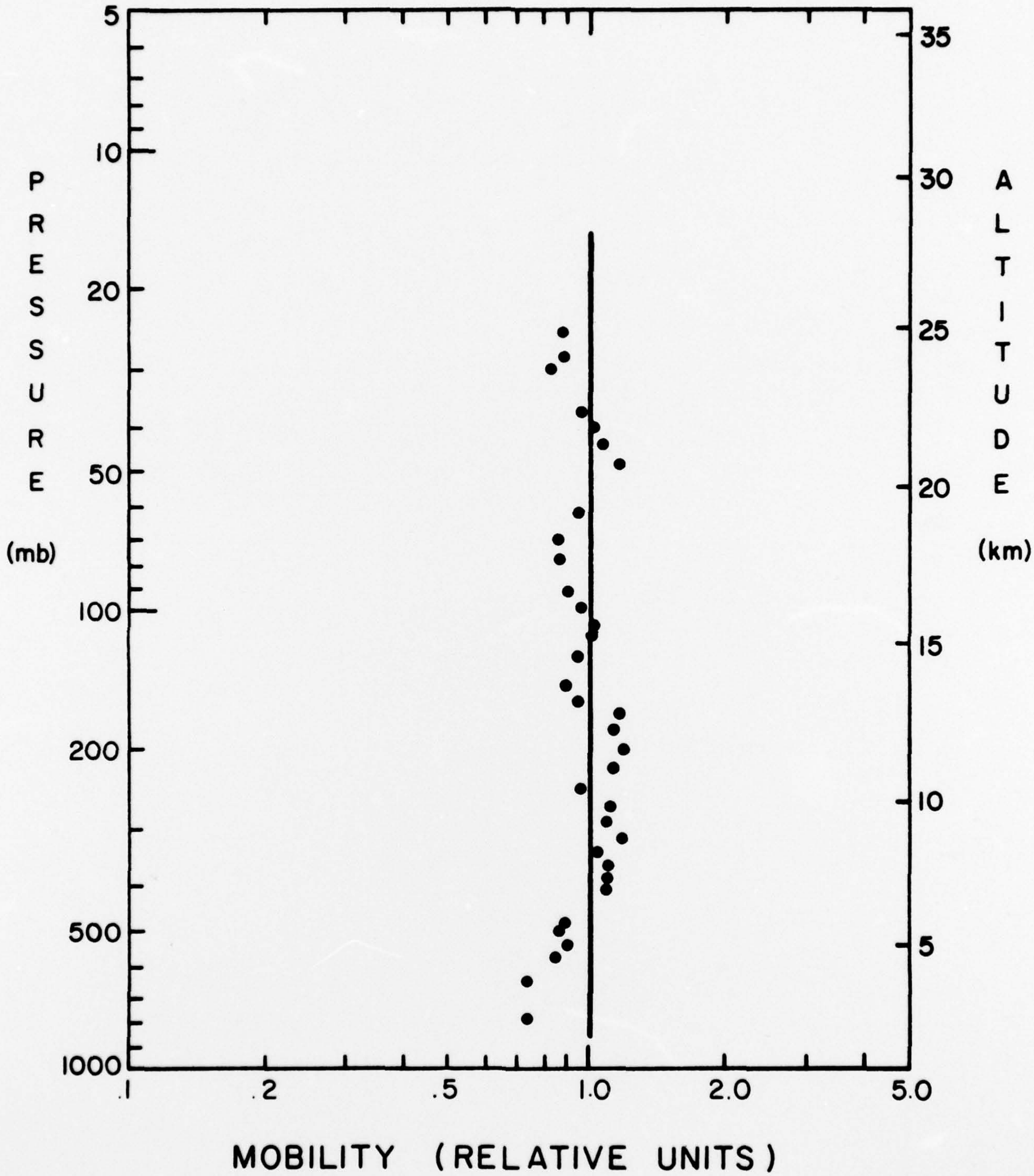

Figure 27. The variation of the mobility as derived from the measurements of flight W - 178.

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4. TITLE (and Subtitle) INFLUENCE OF AEROSOLS ON ELECTRICAL PARAMETERS IN THE FREE ATMOSPHERE		5. TYPE OF REPORT & PERIOD COVERED INTERIM TECHNICAL 8/77 - 8/78 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J.M. Rosen D.J. Hofmann		8. CONTRACT OR GRANT NUMBER(s) Grant No. DAA-G-29-77-G-0046
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of Wyoming Department of Physics and Astronomy Laramie, Wyoming 82071		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Research Office Post Office Box 12211 Research Triangle Park, NC 27709		12. REPORT DATE August, 1978 13. NUMBER OF PAGES 38
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE NA

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Aerosols, Ions, Atmospheric Electrical Parameters

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A force-ventilated device for measuring the small positive ion density from a rising balloon platform in the free atmosphere has been developed and tested on 6 flights. The data from individual soundings indicate that the instrument produces self consistent results but there appears to be long term trends of the apparent stratospheric ion density which may be associated with some unidentified variable.

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